New Nouveau
Brunswick

VOLUME 21, 1999

Agriculture and
Rural Development

Agriculture et
Aménagement rural

ADAPTIVE RESEARCH REPORTS

RAPPORTS DE RECHERCHES SUR L'ADAPTATION

1999

N.B. Department of Agriculture & Rural Development
Ministère de l'Agriculture et de l'Aménagement rural du N.-B.

101-00674/

VOLUME 21, 1999

ISBN No. 1- 55048-807-4

ADAPTIVE RESEARCH REPORTS

RAPPORTS DE RECHERCHES SUR L'ADAPTATION

N.B. DEPARTMENT OF AGRICULTURE & RURAL DEVELOPMENT
MINISTÈRE DE L'AGRICULTURE ET DE L'AMÉNAGEMENT RURAL DU N.-B.
Standing Committee on Adaptive Research
Comité permanent des recherches sur l'adaptation

Claire LePage
Deputy Minister
Sous-ministre

Milton Sherwood
Minister
Ministre

FOREWORD

This is the twenty first volume of the Adaptive Research Reports. Each year the Department of Agriculture and Rural Development publishes the results of research projects conducted for the benefit of farmers and agrologists.

The reports cover technology transfer activities conducted under the Department of Agriculture and Rural Development Adaptive Research Partnership Initiative. The financial funding of the NB Strategic Partnership Development Fund is acknowledged in supporting these research projects.

I wish to acknowledge the efforts of staff in conducting the trials and extend thanks to all producers and organizations that cooperated in the projects. A special recognition is made to Jeanne Badeau for clerical support, and to the print shop staff for printing the report.

This 1999 volume is brought together and published through very capable efforts of the editor, Christopher Maund.

Paul Smith
Chairman, Standing Committee on Adaptive Research
Department of Agriculture and Rural Development
Fredericton, New Brunswick

PRÉFACE

Voici le vingt et unième volume des Rapports de recherches sur l'adaptation. Chaque année, le ministère de l'Agriculture et de l'Aménagement rural publie les résultats des projets de recherches effectués pour le compte des producteurs et des agronomes.

Les rapports visent les activités de transfert de technologies réalisées par le ministère de l'Agriculture et de l'Aménagement rural, dans le cadre des projets de recherches sur l'adaptation. Les fonds provenant du Fonds d'établissement de partenariats stratégiques du Nouveau-Brunswick ont permis d'aider pour ces projets de recherche.

Je tiens à souligner les efforts du personnel qui a mené les essais et à remercier tous les producteurs et organismes qui ont collaboré à l'exécution des projets. Je désire témoigner ma reconnaissance particulièrement à Jeanne Badeau pour son travail de bureau et au personnel de l'imprimerie pour l'impression du volume.

Ce volume des projets de 1999 a été préparé et publié grâce au travail dévoué et compétent du rédacteur, Christopher Maund.

Paul Smith
Président, Comité permanent des recherches sur l'adaptation
Ministère de l'Agriculture et de l'Aménagement rural
Fredericton (Nouveau-Brunswick)

STAFF CONTRIBUTORS / EMPLOYÉS COLLABORATEURS

Potato & Horticulture Branch / Direction de la pomme de terre et de l'horticulture

Guy Bernard	Pest Management Specialist / Spécialiste de la lutte contre les parasites (Wicklow)
Shirlyn E. Coleman	Manager, Plant Propagation Centre / Gestionnaire, Centre de propagation des végétaux
Kelvin Lynch	Plant Pathologist / Phytopathologiste
Christopher Maund	Entomologist / Entomologiste
Kevin McCully	Weed Specialist / Malherbologiste
Michel Melanson	Blueberry Specialist / Spécialiste de la culture des bleuets
Loretta J. Mikitzel	Potato Physiologist / Physiologiste de la pomme de terre (Wicklow)
Lynn M. Moore	Seed Potato Specialist / Spécialiste de la pomme de terre (semence)
Nancy Pothier	Plant Health Technologist / Technologiste de phytosanitaire
Greg Sweetland	Apple and Cranberry Specialist / Spécialiste de la culture des pommes et des canneberges
David Wattie	Manager, Bon Accord Elite Seed Potato Centre / Gestionnaire, Centre de pommes de terre de semence Élite de Bon Accord (Bon Accord)

Land Resources Branch / Direction des ressources des terres agricoles

Daniel Ward	Soil and Water Engineer / Ingénieur des sols et des eaux

Livestock and Livestock Feed Branch / Direction de l'élevage et de l'alimentation des animaux

Mike Price	Forage Specialist / Spécialiste des cultures fourragères
Anthony Smith	Field Crops Technologist / Technologue des grandes cultures
David Walker	Manager, Livestock Feed and Grain Specialist / Gestionnaire, Section de l'alimentation des animaux et Spécialiste des grains

Regional Offices / Bureaux régionaux

Walter Brown	Field Crops Specialist / Spécialiste des grandes cultures (Sussex)
Laurie Collette	Regional Director / Directeur régional (Moncton)
Jacques Lavoie	Potato Production Specialist / Spécialiste de la pomme de terre (Grand Falls)
Janet McLaughlin	Potato Resources Technician / Technicienne en culture de la pomme de terre (Wicklow)
Peter K. Scott	Potato Production Specialist (Table / Processing) / Spécialiste de la pomme de terre (Consommation / transformation) (Wicklow)
Roger Thériault	Field Crop Specialist / Spécialiste des grandes cultures (Moncton)

OTHER CONTRIBUTORS / AUTRES COLLABORATEURS

John Argall	Program Lead-Advanced Agri-Food Technolgies / Chef de programme - Technologies de pointe en agro-alimentaire (BioAtlantech)
Patrice Audy	Research Scientist / Chercheur (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
Roger L. Bernier	Executive Director / Directeur exécutif (BioAtlantech)
David Boyle	President / Président (Maritime MicroBiologicals)
E. Charmley	Research Scientist / Chercheur (Agriculture and Agri-Food Canada - Nappan, NS / Agriculture et Agroalimentaire Canada - Nappan, N.-É.)
T. Lien Chow	Research Scientist / Chercheur (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
E.A. Clark	Associate Professor / Professeur agrégé (University of Guelph / Université de Guelph)
Warren K. Coleman	Research Scientist / Chercheur (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
Q. Davison	Research Assistant / Adjoint à la recherche (New Brunswick Soil and Crop Improvement Association / Association de l'amélioration du sol et des cultures du Nouveau-Brunswick)
Henry DeJong	Research Scientist / Chercheur (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
Sherry Fillmore	Statistician / Statisticienne (Agriculture and Agri-Food Canada - Kentville, NS / Agriculture et Agroalimentaire Canada - Kentville, N.-É.)

Stu Fleischhaker	Producer and Miller / Producteur et meunier (Maritime Certified Organic Growers Co-operative/ Coopératif Certifié Biologique Maritime)
Gilles Godbout	Farm Owner / Propriétaire d'exploitation agricole (Eagle Farm Ltd.)
Rob Gordon	Associate Professor- Engineering / Professeur agrégé - génie (Nova Scotia Agricultural College / Collège d'agriculture de la Nouvelle-Écosse
Muhammad Haroon	Laboratory Technician / Technicien de laboratoire (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
J.A. Ivany	Researcher / Chercheur (Agriculture and Agri-Food Canada - Charlottetown, PEI / Agriculture et Agroalimentaire Canada - Charlottetown, I-P-É)
Steven K. Javorek	Research Biologist / Biologiste (Diversified Pollination Systems)
W. Kalt	Researcher / Chercheuse (Agriculture and Agri-Food Canada - Kentville, NS / Agriculture et Agroalimentaire Canada - Kentville, N.-É.)
Xiu Q. Li	Researcher / Chercheur (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
V. Little	Farm Manager / Gérant d'exploitation agricole (River Valley Cranberry Company Inc.)
Keith MacAloney	Field Biologist / Biologiste (Canadian Wildlife Service, Environment Canada / Service canadien de la faune, Environnement Canada)
Dawn MacLoon	Research Assistant / Adjointe à la recherche (New Brunswick Soil and Crop Improvement Association / Association de l'amélioration du sol et des cultures du Nouveau-Brunswick)
Chantal Matar	Professor / Professeur (University of Moncton / Université de Moncton)

Amber C. McCulley	Laboratory Technician / Technicienne de laboratoire (BioAtlantech)
Ken D. McRae	Statistician / Statisticien (Agriculture and Agri-Food Canada - Kentville, NS / Agriculture et Agroalimentaire Canada - Kentville, N.-É.)
Reg Melanson	Field Biologist /Biologiste (Canadian Wildlife Service, Environment Canada / Service canadien de la faune, Environnement Canada)
Agnes M. Murphy	Research Scientist / Chercheuse (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada- Fredericton, NB)
Cynthia Murray	Technician / Technicienne (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
Y.A. Papadopoulos	Researcher / Chercheur (Agriculture and Agri-Food Canada - Charlottetown, PEI/ Agriculture et Agroalimentaire Canada - Charlottetown, I-P-É)
K. Patterson	Weed Research Assistant / Malherbologiste adjoint (Department of Environmental Sciences, Nova Scotia Agricultural College / Département des sciences environnementales, Collège d'agriculture de la Nouvelle-Écosse)
Boyd Peters	General Manager / Directeur général (River Valley Cranberry Company Inc.)
Herb Rees	Researcher / Chercheur (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
Vernon Rodd	Researcher / Chercheur (Agriculture and Agri-Food Canada - Nappan, NS / Agriculture et Agroalimentaire Canada - Nappan, N.-É.)
P. Roy	Research Assistant / Adjoint à la recherche (Université de Moncton / University of Moncton)

M.G. Sampson	Associate Professor / Professeur agrégé (Department of Environmental Sciences, Nova Scotia Agricultural College / Département des sciences environnementales, Collège d'agriculture de la Nouvelle-Écosse)
Pamela Sandeson	Research Assistant / Adjointe à la recherche (New Brunswick Soil and Crop Improvement Association / Association de l'amélioration du sol et des cultures du Nouveau-Brunswick)
Charles B. Schom	President / Président (Surge Inc.)
Jennifer Scott	Project Coordinator and crop technican / Coordonnatrice de projet et technicienne des cultures (Maritime Certified Organic Growers Co-operative / Co-opératif Certifié Biologique Maritime)
Mathuresh Singh	Director of Administration and Research / Directeur d'administration et recherche (Agricultural Certification Services Inc./N.B. Potato Agency / Agricultural Certification Services Inc./Agence de la pomme de terre du Nouveau-Brunswick)
Birt Stevens	Technician / Technicien (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
George C.C. Tai	Research Scientist / Chercheur (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
T. Richard Tam	Research Scientist / Chercheur (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)
K.M. Thomas	Research Biologist / Biologiste (Cumberland County Soils and Crops Improvement Association / Association pour l'amélioration du sol et des cultures du comté de Cumberland)
Esther Tremblay-Deveau	Plant Physiology Technician / Technicienne en physiologie des plantes (Agriculture and Agri-Food Canada - Fredericton, NB / Agriculture et Agroalimentaire Canada - Fredericton, NB)

Brad Walker	Statistician / Statisticien (Agriculture and Agri-Food Canada - Kentville, NS / Agriculture et Agroalimentaire Canada - Kentville, N.-É.)
Ken Webb	Researcher / Chercheur (Agriculture and Agri-Food Canada - Truro, NS / Agriculture et Agroalimentaire Canada - Truro, N.-É.)
Jason Wells	Technician / Technicien (Cumberland County Soil and Crop Improvement Association / Association pour l'amélioration du sol et des cultures du comté de Cumberland)
John Wile	Field Biologist / Biologiste (Ducks Unlimited Canada - Amherst, NS / Canards Illimités Canada, Amherst, N.-É.)

TABLE OF CONTENTS / TABLE DES MATIÈRES

FOREWORD / PRÉFACE: Chairman / Président iii

STAFF CONTRIBUTORS / EMPLOYÉS COLLABORATEURS ....v-vi

OTHER CONTRIBUTORS / AUTRES COLLABORATEURS ....vii-xi

GENERAL / GÉNÉRAL

INDUSTRIAL HEMP GROWTH TRIALS - NEW BRUNSWICK 1999 /
ESSAIS DE CULTURE DU CHANVRE INDUSTRIEL AU NOUVEAU-BRUNSWICK EN 1999
C. Schom 1-41
(Partner/Partenaire: Surge Inc.)

PROFITABLE PRODUCTION OF SPECIALTY MUSHROOMS ON SUBSTRATES AVAILABLE IN NEW BRUNSWICK /
PRODUCTION RENTABLE DE CHAMPIGNONS SPÉCIAUX DANS DES SUBSTRATS ACCESSIBLES AU NOUVEAU-BRUNSWICK
D. Boyle 43-60
(Partner/Partenaire: Maritime MicroBiologicals)

CEREALS AND PROTEIN CROPS / CÉRÉALES ET CULTURES PROTÉAGINEUSES

SOIL TILLAGE MANAGEMENT OF DYKELAND SOILS FOR BETTER CROP DIVERSIFICATION AND WILDLIFE USE - EFFECT ON AGRONOMIC PERFORMANCE /
GESTION DU TRAVAIL DES SOLS MARÉCAGEUX POUR AMÉLIORER LEUR DIVERSIFICATION VÉGÉTALE ET LEUR UTILISATION PAR LA FAUNE - EFFET SUR LA PERFORMANCE AGRONOMIQUE
V. Rodd, J. Wells, R. Thériault, H. Rees, L. Chow, K. Webb, K. McRae, K. MacAloney, J. Wile, R. Melanson, L. Collette, R. Gordon, S. Fillmore and/et B. Walker..........61-68
(Partners/Partenaires: Phillip Pederson (Philarik Acres Ltd.), Robert Acton (R.A. Farms), Terry Lister (CORCAN), Chignecto Soil and Crop Improvement Association, Cumberland County Soil and Crop Improvement Association, Ducks Unlimited and Eastern Habitat Joint Venture / Phillip Pederson (Philarik Acres Ltd.), Robert Acton (R.A. Farms), Terry Lister (CORCAN), Association pour l'amélioration du sol et des cultures de Chignecto, Association pour l'amélioration du sol et des cultures du comté de Cumberland, Canards Illimités Canada et Eastern Habitat Joint Venture)

HYBRID CANOLA SEED HARVEST MANAGEMENT STUDY - NEW BRUNSWICK, 1999 /
ÉTUDE SUR LA TECHNIQUE DE RÉCOLTE DES GRAINES DE CANOLA HYBRIDE - NOUVEAU BRUNSWICK, 1999
D.F. Walker, D. MacLoon, A.O.M. Smith and/et P.D. Sandeson 69-75
(Partner/Partenaire: New Brunswick Soil and Crop Improvement Association / L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick)

WINTER AND SPRING CEREAL AND PROTEIN CROP CULTIVAR EVALUATION, HARTLAND, N.B. 1999 /
ÉVALUATION DE CULTIVARS DE CÉRÉALES D'HIVER ET DE PRINTEMPS ET DE CULTURES PROTÉAGINEUSES, HARTLAND (N.-B.) 1999
D.F. Walker, A.O.M. Smith and/et P.D. Sandeson 77-89
(Partner/Partenaire: New Brunswick Soil and Crop Improvement Association / L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick)

EVALUATION OF ROUNDUP TRANSORB ON ROUNDUP READY SOYBEANS GROWN IN NEW BRUNSWICK (1999) /
ÉVALUATION DU ROUNDUP TRANSORB SUR LE SOYA ROUNDUP READY CULTIVÉ AU NOUVEAU-BRUNSWICK (1999)
K.V. McCully, M. Melanson, N. Pothier and/et D.F. Walker.................................91-96
(Partners/Partenaires: New Brunswick Soil and Crop Improvement Association and Monsanto / Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick et Monsanto)

STRAW YIELD AND OTHER AGRONOMIC CHARACTERISTICS OF RECOMMENDED SPRING WHEAT, OAT, SIX-ROW AND TWO-ROW BARLEY CULTIVARS, HARTLAND, N.B. 1999 /
RENDEMENT DE PAILLE ET AUTRES PARTICULARITÉS AGRONOMIQUES DE CULTIVARS RECOMMANDÉS DE BLÉ DE PRINTEMPS, D'AVOINE, D'ORGE À SIX RANGS ET D'ORGE À DEUX RANGS - HARTLAND (N.-B.) 1999
D.F. Walker, A.O.M. Smith and/et P.D. Sandeson 97-101
(Partner/Partenaire: New Brunswick Soil and Crop Improvement Association and Advanta Seeds Inc. / Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick et Advanta Seeds Inc.)

EVALUATION OF SPRING MILLING WHEAT CULTIVARS FOR ORGANIC PRODUCTION AT SPEERVILLE, DEBEC, HAVELOCK AND SOUTH BRANCH, 1999 /
ÉVALUATION DE CULTIVARS DE BLÉ DE MOUTURE DE PRINTEMPS POUR UNE PRODUCTION DE TYPE BIOLOGIQUE À SPEERVILLE, DEBEC, HAVELOCK ET SOUTH BRANCH 1999
D.F. Walker, A.O.M. Smith, J. Scott and/et S. Fleischhaker 103-113
(Partner/Partenaire: Maritime Certified Organic Growers Co-operative / Co-opératif Certifié Biologique Maritime)

FORAGE CROPS / FOURRAGES

DEVELOPMENT AND EVALUATION OF FORAGE CROP MANAGEMENT SYSTEMS, NEW BRUNSWICK 1999 /
MISE AU POINT ET ÉVALUATION DE SYSTÈMES DE GESTION DES CULTURES FOURRAGÈRES - NOUVEAU-BRUNSWICK 1999
M. Price, W. Brown, A.O.M. Smith and/et Q. Davison 115-122
(Partner/Partenaire: New Brunswick Soil and Crop Improvement Association /
L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick)

FORAGE CULTIVAR EVALUATION IN ATLANTIC CANADA, 1999 /
ÉVALUATION DE CULTIVARS DE FOURRAGE AU CANADA ATLANTIQUE 1999
M. Price, W. Brown, A.O.M. Smith and/et Q. Davison 123-137
(Partner/Partenaire: New Brunswick Soil and Crop Improvement Association /
L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick)

THE EVALUATION OF ALFALFA CULTIVARS UNDER HAY AND PASTURE MANAGEMENT SYSTEMS /
ÉVALUATION DE CULTIVARS DE LUZERNE DANS DES SYSTÈMES D'EXPLOITATION DE FOURRAGE ET DE PÂTURAGE
Y.A. Papadopoulos, R. Thériault, M. Price, K.D. McRae, E.A. Clark,
K.M. Thomas, S.A.E. Fillmore and/et E. Charmley 139-151
(Partner/Partenaire: Moncton Soil and Crop Improvement Association / L'Association pour l'amélioration du sol et des cultures de Moncton)

THE EVALUATION OF FORAGE MIXTURES TO IMPROVE LEGUME SPECIES SURVIVAL ON LAND-FORMED DYKELAND /
ÉVALUATION DE MÉLANGES FOURRAGERS POUR AMÉLIORER LA SURVIE D'ESPÈCES DE LÉGUMINEUSES DANS LES TERRES MARÉCAGEUSES CULTIVABLES
Y.A. Papadopoulos, R. Thériault, M.Price, K.M. Thomas, S.A.E. Fillmore
and/et V. Rodd 153-161
(Partner/Partenaire: Chignecto Soil and Crop Improvement Association / Association pour l'amélioration du sol et des cultures du Chignecto)

EVALUATION OF VARIOUS HERBICIDES ON AUBADE AND BARSPECTRA RYEGRASS GROWN FOR SEED /
RAYGRASS BARSPECTRA CULTIVÉ POUR LA SEMENCE
K.V. McCully, J.A. Ivany, M. Melanson, M. Price and/et A. Smith 163-169
(Partner/Partenaire: New Brunswick Soil & Crop Improvement Association /
L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick)

PEST MANAGEMENT / LUTTE ANTI-PARASITAIRE

CONTROL OF LEAF SPOT AND POWDERY MILDEW IN WILD BLUEBERRY /
CONTRÔLE DE LA TACHE DES FEUILLES ET DU BLANC DU BLEUET SAUVAGE
K. Lynch and/et M. Melanson 171-172

CRANBERRY INSECT PEST MONITORING IN NEW BRUNSWICK, 1999 / DÉPISTAGE DES INSECTES NUISIBLES À LA CANNEBERGE AU NOUVEAU-BRUNSWICK 1999
C.M. Maund 173-187
(Partner/Partenaire: NB Cranberry Grower's Association / L'Association des producteurs de canneberges du Nouveau-Brunswick)

EVALUATION OF THE PERFORMANCE OF FUNGICIDES ON GRAIN YIELD AND LEAF DISEASES ON SPRING WHEAT - NEW BRUNSWICK 1999 / ÉVALUATION DE L'EFFET DE FONGICIDES SUR LE RENDEMENT GRAINIER ET SUR LES MALADIES FOLICOLES DU BLÉ DE PRINTEMPS - NOUVEAU-BRUNSWICK 1999
D.F. Walker, P.D. Sandeson and/et A.O.M. Smith 189-193
(Partners/Partenaires: New Brunswick Soil and Crop Improvement Association, Novartis Crop Protection Canada Inc. / Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick et Novartis Crop Protection Canada Inc.)

MONITORING OF INSECT POPULATIONS IN POTATO FIELDS IN 1999 / DÉPISTAGE DES POPULATIONS D'INSECTES DANS LES CHAMPS DE POMMES DE TERRE EN 1999
G. Bernard 195-201

AERIAL MONITORING OF POTATO INFESTING APHIDS IN NEW BRUNSWICK IN 1999 / DÉPISTAGE AÉRIEN DES PUCERONS INFESTANT LA POMME DE TERRE AU NOUVEAU-BRUNSWICK EN 1999
G. Bernard 203-207

CONTROL OF COMMON LEAF SPOT IN STRAWBERRY / LUTTE CONTRE LA TACHE COMMUNE DANS LES FRAISIERS
K. Lynch 209-211

WEED MANAGEMENT IN CRANBERRY / LUTTE CONTRE LES MAUVAISES HERBES DANS LES CANNEBERGIÈRES
K. Patterson and/et M. G. Sampson 213-225
(Partners/Partenaires: New Brunswick Cranberry Growers Association and Nova Scotia Cranberry Growers Association / L'Association des producteurs de canneberges du Nouveau-Brunswick et l'Association des producteurs de canneberges de la Nouvelle-Écosse)

EVALUATION OF WEED CONTROL METHODS FOR USE ON GILBERT ISLAND PASTURES / ÉVALUATION DE MÉTHODES DE LUTTE CONTRE LES MAUVAISES HERBES POUR LES PÂTURAGES DE L'ÎLE GILBERT
K.V. McCully, D. Ward and/et W. Brown 227-233
(Partner/Partenaire: Sussex and Studholm Agricultural Society)

POTATOES / POMMES DE TERRE

OPTIMIZATION OF A PCR METHOD FOR FINGERPRINTING POTATO VARIETIES /
OPTIMISATION D'UNE MÉTHODE PCR POUR LA CARTOGRAPHIE DE VARIÉTÉS DE POMMES DE TERRE
X-Q Li, S. Coleman, B. Stevens, M. Haroon 235-240
(Partner/Partenaire: Potato Research Centre, Agriculture and Agri-Food Canada / Centre de recherche sur la pomme de terre, Agriculture et Agroalimentaire Canada)

TESTING THE EFFECTIVENESS OF BIOPRODUCT XL AND XH AND PRODUCT AG ON GROWTH AND YIELD OF POTATO /
ESSAI DES BIOPRODUITS XL ET XH ET DU PRODUIT AG SUR LA CROISSANCE ET LE RENDEMENT DES POMMES DE TERRE
L.J. Mikitzel 241-252
(Partner/Partenaire: BioAtlantech, Bios Agriculture)

IMPROVING COLOUR OF POTATO FRENCH FRIES AND CHIPS BY ENZYMATIC MODIFICATION OF REDUCING SUGARS /
L'AMÉLIORATION DE LA COULEUR DES FRITES ET DES CROUSTILLES DE POMME DE TERRE PAR UNE MODIFICATION ENZYMATIQUE DES SUCRES RÉDUCTEURS
A.C. McCulley, P. Audy, G. Tai, C. Matar and/et R.L. Bernier 253-271
(Partners/Partenaires: Agriculture and Agri-Food Canada and Université de Moncton / Ministère de l'Agriculture et de l'Agroalimentaire Canada et Université de Moncton)

EVALUATING POTATO PLANTLET PREPARATION PROCEDURES FOR NUCLEAR SEED PRODUCTION /
EVALUATION DE MÉTHODES DE PRÉPARATION DES PLANTULES DE POMMES DE TERRE DESTINÉS À LA PRODUCTION DE SEMENCES DE DÉPART
L.J. Mikitzel 273-281
(Partner/Partenaire: Mr. Robert Watson, Salmon River Farm)

ACCELERATED RELEASE FRENCH FRY CLONE EVALUATION, WOODSTOCK, NB 1998 -1999 /
ÉVALUATION DE CLONES DE POMMES DE TERRE APTES À LA PRODUCTION DE FRITES EN VUE D'UNE MISE EN CIRCULATION ACCÉLÉRÉE, WOODSTOCK (N.-B.) 1998-1999
P.K. Scott and/et J. McLaughlin 283-294
(Partner/Partenaire: New Brunswick Potato Agency (SPUDTECH) / Agence de la Pomme de Terre du Nouveau Brunswick (SPUDTECH))

EVALUATING SEEDPIECE TREATMENT EFFECTS ON PLANT STAND /
EVALUATION DES EFFETS DE TRAITEMENTS DES SEMENCES SUR LE PEUPLEMENT
L.J. Mikitzel and/et P.K. Scott 295-300
(Partner/Partenaire: New Brunswick Potato Agency / Agence de la pomme de terre du Nouveau-Brunswick)

OPTIMIZING THE ECONOMICAL RETURN OF POTATOES THROUGH GREENSPROUTING AND SPACING /
OPTIMISATION DE LA RENTABILITÉ DES POMMES DE TERRE GRÂCE À LA PRÉGERMINATION ET À L'ESPACEMENT
L.M. Moore 301-315
(Partner/Partenaire: New Brunswick Seed Potato Growers' Association / Association des producteurs de pommes de terre de semence du Nouveau-Brunswick)

EARLY POTATO VARIETY DEVELOPMENT - SPUDTECH 1999 /
MISE AU POINT DE VARIÉTÉS DE POMMES DE TERRE HÂTIVES - SPUDTECH 1999
L.M. Moore 317-329

NATUREMARK™ KYLE EVALUATION, HARTLAND, NB 1999 /
ÉVALUATION DE CLONES KYLE DE NATUREMARK^{MC}, HARTLAND (N.-B.) 1999
P.K. Scott and/et J. McLaughlin 331-334
(Partner/Partenaire: New Brunswick Potato Agency (SPUDTECH) / Agence de la pomme de terre du Nouveau Brunswick (SPUDTECH))

PERFORMANCE EVALUATION OF POTATO CLONES AND VARIETIES IN THE NORTHEAST, NE-184, HARTLAND, NB - 1999 /
ÉVALUATION DE LA PERFORMANCE DE CLONES ET DE VARIÉTÉS DE POMMES DE TERRE DANS LE NORD-EST, NE-184, HARTLAND (N.-B.) 1999
P.K. Scott, H. DeJong, T.R. Tam, G.C.C. Tai, A.M. Murphy and/et C. Murray 335-340

EFFECT OF MUSTER HERBICIDE CARRYOVER ON VARIOUS POTATO VARIETIES /
ARRIÈRE-EFFET DE L'HERBICIDE MUSTER SUR DIVERSES VARIÉTÉS DE POMMES DE TERRE
K.V. McCully, P. Scott, J. Lavoie and/et G. Godbout 341-352

DIFFERENCES IN STORAGE QUALITY BETWEEN ELEVEN RUSSET BURBANK CLONES /
DIFFÉRENCES DANS LA QUALITÉ DE CONSERVATION DE ONZE CLONES DE RUSSET BURBANK
W.K. Coleman, D. Wattie, X.Q. Li, E. Tremblay-Deveau and/et S.E. Coleman 353-357

POST HARVEST TEST FOR DORMANT TUBERS /
CONTRÔLE APRÈS RÉCOLTE POUR TUBERCULES DORMANTS
Mathuresh Singh 359-370

SMALL FRUIT / PETITS FRUITS

DEVELOPMENT OF AN ENVIRONMENTAL MANAGEMENT STRATEGY FOR THE CONSERVATION AND ENHANCEMENT OF INDIGENOUS BEES WITHIN THE NEW BRUNSWICK WILD BLUEBERRY AGRO-ECOSYSTEM /
ÉLABORATION D'UNE STRATÉGIE DE GESTION DE L'ENVIRONNEMENT POUR PRÉSERVER ET AMÉLIORER L'ÉTAT DES ABEILLES INDIGÈNES DANS L'AGROÉCOSYSTÈME DES BLEUETS SAUVAGES AU NOUVEAU-BRUNSWICK
S.K. Javorek 371-402
(Partner/Partenaire: New Brunswick Wild Blueberry Growers Association / L'Association des producteurs de bleuets sauvages du Nouveau-Brunswick)

MAXIMIZING PHENOL YIELD FROM WILD BLUEBERRY FRUIT THROUGH FERMENTATION AND BIO-TRANSFORMATION /
LA BIO-TRANSFORMATION DU BLEUET SAUVAGE AFIN DE MAXIMISER LA PRODUCTION DE PHÉNOLS
C. Matar, P. Roy, W. Kalt, R. Bernier and/et J. Argall 403-412
(Partner/Partenaire: BioAtlantech Inc./Vaccinium Technologies Inc.)

EVALUATION OF CASORON 4G FOR USE ON SANDED AND NON-SANDED CRANBERRY BEDS /
ÉVALUATION DU CASORON 4G DANS DES PARCELLES DE CANNEBERGE SABLÉES ET NON SABLÉES
K.V. McCully, V. Little, B. Peters and/et N. Pothier 413-421

TREE FRUIT / D'ARBRES FRUITIERS

A DEMONSTRATION OF THE EFFICACY OF DIVERSIONARY FENCING IN AN ORCHARD WITH A HISTORY OF SERIOUS DEER DAMAGE /
EFFICACITÉ D'UNE CLÔTURE DE PROTECTION CONTRE LES CHEVREUILS DANS UN VERGER
G. Sweetland 423-428
(Partner / Partenaire : New Brunswick Apple Marketing Board / Producteurs de pommes du Nouveau-Brunswick)

GENERAL / GÉNÉRAL

INDUSTRIAL HEMP GROWTH TRIALS - NEW BRUNSWICK 1999

ESSAIS DE CULTURE DU CHANVRE INDUSTRIEL AU NOUVEAU-BRUNSWICK EN 1999

Charles Schom[1]

Partner / Partenaire : Surge Inc.

Abstract: This was the second year a project designed to evaluate industrial hemp as a crop suited to New Brunswick. The four cultivars grown this year were the German Fasamo, French Fedora 19 and Felina 34, using Uniko -B as a year to year control. Each was grown on a quarter acre which in turn was divided into four fertilizer treatments. The design was repeated nine times i.e. run at nine sites around New Brunswick. Height and dry weight yield did not correlate as closely this year as year. The experiment conformed to a four way factorial analysis of variance. In contradistinction to last year statistically significant differences existed for the differences between cultivars and sites as well as date and fertilizer. Compaction analyzed as a comparison between rolling and not rolling following planting was statistically significant and interacted with cultivar. Fedora and Uniko preformed better when not rolled, Felina and Fasamo performed better when rolled. In 1999 moisture was insufficient for long periods yet 5 tons an acre was realized. There were no crop wide failures attributable to lack of moisture alone. Due to an error in the headings of one of the tables last year, yields were underestimated, weights given as pounds per acre were actually kg per ½ acre, which means the actual high yields last year were in the range of 9 tons per acre. Yield, dry matter per acre, this year from sites weight sampled approached 8 tons per acre. Calculated yields for other sites surpassed that. This was true both for the conventional fertilizer treatment and for organic fertilizers. It takes 10 tons of composed cow manure per acre to get that kind of growth. The maturing heads of the Fedora and Felina were attacked by fungus, *Botrytis cinerea*, *Scletoyinia (sp) and Alternaria (sp)* which prevented normal seed maturation. Fasamo produced good seed crops at 5 of the 9 sites. It seemed resistant to fungus and lodging, European corn borer caused problems in other cultivars. Other issues are raised and discussed Most significant is the need to reduce genetic variability within the cultivars.

Résumé : Le projet, qui en était à sa deuxième année, avait pour but d'évaluer les possibilités de culture du chanvre industriel dans les conditions du Nouveau-Brunswick. Les quatre cultivars utilisés durant l'année étaient German Fasamo, French Fedora 19, Felina 34 et Uniko –B, qui sert de variété témoin d'année en année. Chaque variété a été semée sur un quart d'acre subdivisé en quatre pour les traitements fertilisants. Le dispositif a été répété neuf fois, c'est-à-dire à neuf endroits différents du Nouveau-Brunswick. La hauteur des plants et le rendement poids sec n'étaient pas aussi corrélatifs que l'année précédente. L'expérience a été faite conformément à une analyse factorielle quadruple de la variance. Contrairement à l'année dernière, des écarts importants ont été relevés dans les paramètres à l'étude, soit le cultivar, le site, la date et l'engrais. On a aussi analysé la mesure dans laquelle le passage des rouleaux après le semis a influé sur le compactage du sol, pour constater que le compactage était statistiquement significatif et qu'il a eu des effets sur les cultivars. Fedora et Uniko ont donné un meilleur rendement sans le passage des rouleaux, tandis que Felina et Fasamo ont donné statistiquement un bien meilleur rendement avec le passage des rouleaux. L'humidité était insuffisante pendant de longues périodes cette année, mais le rendement a quand même été de 5 tonnes l'acre. Aucune perte de récolte n'était attribuable au seul facteur du manque d'humidité. À cause d'une erreur faite l'an dernier dans l'en-tête d'une colonne d'un des tableaux, où l'on indiquait le poids en livres par acre plutôt qu'en kilogrammes par acre, les rendements ont été sous-estimés, et les rendements supérieurs de l'an dernier étaient effectivement de l'ordre de 9 tonnes l'acre. Cette année, les rendements en matière sèche aux endroits échantillonnés s'établissaient à près de 8 tonnes l'acre. Les rendements calculés aux autres endroits étaient plus élevés, notamment dans le cas du traitement fertilisant habituel et des engrais organiques. Il faut appliquer 10 tonnes de fumier de vache composté par acre pour obtenir ce résultat. Les inflorescences des variétés Fedora et Felina ont été attaquées par les agents fongiques *Botrytis cinerea*, *Scletoyinia (sp)* et *Alternaria (sp)*, qui ont empêché le mûrissement normal des graines. La variété Fasamo a donné un bon rendement grainier à cinq des neuf sites. Elle semble résistante aux agents fongiques et à la verse. La pyrale du maïs a nui à d'autres cultivars. On a soulevé et discuté d'autres questions. Le point le plus important est la nécessité de réduire la variabilité génétique dans les cultivars.

---

[1] Surge Inc., 157C Water Street, Saint Andrews, NB E5B 1A7

Introduction

Background. Industrial hemp fibre was the engine of trade and commerce at the turn of the century. It was the fibre that made the sails that powered the ships, it was the fibre that made the rope, the clothes, the shoes, etc. that the working people wore. It was used to make the paper that bibles and fine books were written on (Kolander, 1995).

Hemp production declined through the 1930's. Cotton and wool processing were mechanized while hemp processing remained dependent on manual labor. This coupled with prohibition that swept the USA and the fear that marijuana might corrupt the youth led, in 1938, to Canadian laws prohibiting the growth of hemp (Twomey, 1995). The law was set aside starting in 1941 as fibre was needed for the war effort only to be banned again once the war need had ended. It was again grown in Canada under research licenses in 1995 increasing from 10 license in 1995 to 31 in 1997 (Health Canada, 1997). In 1998 and 1999 Industrial hemp was grown commercially with thousands of acres under cultivation. Industrial hemp missed the rigorous agronomic, genetic and biological, assessment other crop species in North America were subjected to between 1943 or so and 1997 as none was grown in North America during that period.

As of April 1, 1998 new legislation was brought down by the Canadian federal government allowing the commercial cultivation of industrial hemp. This legislation sets a minimum size of about 10 acres for a grower. Thus, any smaller area must be grown under the Research License.

Hemp is a very versatile plant. Its seed protein contains all of the essential amino acids man needs as well as the two essential fatty acids and contrary to Clarke (1981) the seed tastes good. Its stock produces three size fibres, a long fibre ideal for textiles and twine, a medium fibre about the length of softwood fibre and a short fibre about the length of hardwood fibre. Further the chemical components are ideal for things like rayon and cellophane (Bocsa and Karus, 1997).

Hemp was grown in New Brunswick in the first half of the century. In trials at experimental stations across Canada, including Fredericton growth and fibre production were adequate, but seed set was poor, in particular at Fredericton (Gehl, 1995). Unfortunately, the strains used in those trials no longer exist, thus trials were undertaken to determine the growth potential in New Brunswick of available strains.

Schom (1998) reported that the present strains of industrial hemp could be grown in New Brunswick. It did appear possible to grow a commercially viable crop of fibre but no commercially viable seed crop was produced. The farm equipment on hand did seem able to cultivate and harvest industrial hemp, not without difficulty but still possible. There were a number of conditions that impacted on growth and included rain fall, disease, fertilizer, compaction, soil composition, plus interactions and other factors not identified. Finally, field retting did not seem to work well.

This study focused on issues raised in the 1998 trial with the overall objective to determine under what conditions a commercially viable crop could be produced. The first objective was to determine, with a little greater precision, just how much nitrogen is beneficial and/or has a negative impact. A second objective was to assess the impact of compaction. A third objective was to follow seed production and see if there was any potential or if fungal attack would prevent realizing a commercially viable crop on an ongoing basis. A fourth objective was to identify level of organic fertilization necessary to grow a commercially viable crop. Finally, all of the objectives from the 1998 study were present with the ongoing intention of increasing the pool of farmers with some industrial hemp farming experience.

Materials and Methods

Nine farmers agreed to grow an acre of industrial hemp and follow the experimental design, thus participate in the study. The farms were in very different regions in New Brunswick including areas not present in 1998, thus provide an excellent sample of growing conditions within the province. The sites were near Woodstock, South Tilley, Dunlop North (Bathurst), Riviere-a-la-Truite, Alderwood, Shippigan, Mirimachi City and McKees Mills. For those not familiar with New Brunswick maybe noting that driving the circuit covered 1,250 kilometres will help give a sense of just how large a geographic area was represented.

Each farmer planted four cultivars. The fibre cultivars was the Hungarian strain Uniko-B. As it was grown in the 1998 trial it served as a year to year control also. The duel purpose strains (for both fibre and seed) was the French strain Felina 34. The grain strains were the French strain Fedora 19 and the German strain Fasamo. Uniko - B, the fibre strain, was planted at 60 lb. per acre, down 10 lb. per acre from 1998. Felina 34, the duel purpose strain, was planted at 40 lb. per acre. Fedora 19 and Fasamo, the two grain varieties were planted at 40 lb. per acre, down 10 lb. per acre over 1998.

The effect of conventional fertilizer was addressed by using four fertilizer treatments at each site. Each farm was divided into four equal sections with a different fertilizer treatment applied, at random, to each. One had no fertilizer applied, this was the control, the other three had 550 kg/ha of 12 - 24 - 24 applied. One quarter received only the fertilizer, it was the fertilizer control. Two weeks post planting a fertilized quarter got 150 kg/ha of urea, another fertilized quarter got 250 kg/ha urea. Treatments were randomized within cultivar which were randomized within farm (Figure 1, Table 1).

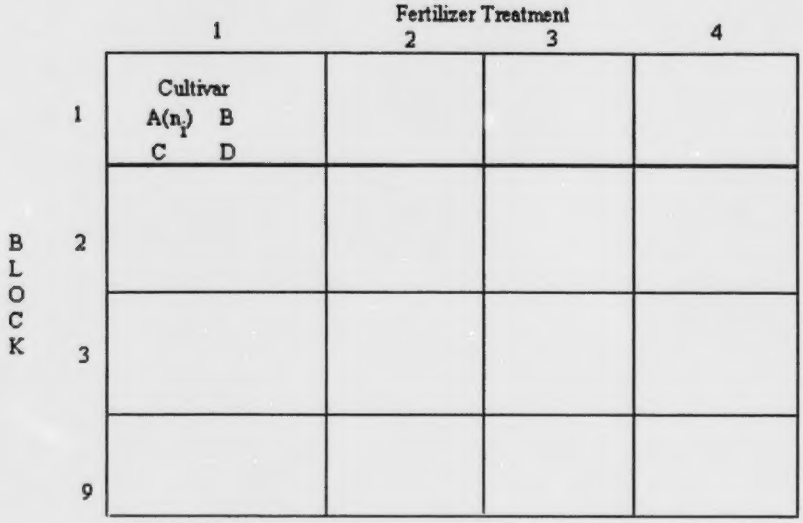


Figure 1. A diagrammatic representation of the experimental design including the factors, farm (block), fertilizer, cultivar but not rolled which was a division of the block in half. Measurements were taken every week or so which accounts for the last block, date.

The effect of organic fertilizer was examined at three farms. Two of the farms applied about 1000 lb. manure per acre. One applied about 20,000 lb. composted manure per acre.

A growth supplement was to be applied in addition mirroring the conventional treatment but the growers did run into problems applying it (Table 1).

Table 1. Fertilizer treatments applied at each of the sites

		Fertilizer					
	Zero	(12-24-24) @ 550 kg/ha (490 lb/ac)			Manure		
Site			Urea @ 150 kg/ha (120 lb/ac)	250 kg/ha 220 lb/ac)	Turkey @ 1125 kg/ha (1000lb/ac)	Cow @ 1125 kg/ha 1000 lb/ac	Cow @ 10 t/ha (10 t/ac)
B	X	X	X	X			
H	X	X	X	X		X	
J	X	X	X	X			
L	X	X	X	X			
M	X	X					
O	X	X	X	X			
R	X	X	X	X			
S	X						X
W	X				X		X

One site, H, had been in the project in 1998. The acre and one half used last year was allowed to self-seed, licensed and germinate in 1999. The growth of the volunteers was recorded and is reported here.

The factorial design was chosen because land, cultivar and fertilizer treatment were selected rather then chosen at random from all possible available. Each block was about one acre in size. This size was chosen as it seemed large enough for the participants to use their farm equipment, yet small enough so that no one had to invest a great deal of time or money in the project. The emphasis was on using farm equipment at hand rather then garden size equipment so that experience was gained using the farm equipment with industrial hemp.

The individual plants measured at a site within a treatment formed the replications. The sample site within a treatment and cultivar were generated by setting a grid and selecting 16 sampling sites at random from the grid where rolled/unrolled was not a treatment, i.e. a sample site within each cultivar within a treatment. Where possible, the same initially randomly selected individual plants at the sampling sites were measured for height approximately weekly. The weekly measurements added another level, time/date, to the factorial design. One half of the area planted with a cultivar was rolled, the other half left unrolled. This added yet another level to the factorial design and doubled the sampling sites to 32.

Soil type and condition's impact on growth was investigated by comparing results between sites given the same treatment to determine just how much of an advantage fertilizer could give. Soil was tested at the beginning of the trial.

The data set (over 21,000 data points) and subsequent analysis were too large for the computer, at hand; therefore the analysis had to be broken into parts. After consideration the break was made so that either acre or rolled/not rolled were analysed for. Thus, M, in the model, was designated either acre for the analysis which included a comparison of sites or rolled for the analysis which included the impact of rolling the ground after planting.

The factorial experimental design model was:

$$X_{hijk} = \mu + T_h + M_i + B_j + P_k + (TM)_{hi} + (TB)_{hj} + (TP)_{hk} + (MB)_{ij} + (MP)_{ik} + (BP)_{jk}$$
$$+ (TMB)_{hij} + (TBP)_{hjik} + (MBP)_{ijk} + (TMBP)_{hijk} + \delta_{hijk}$$

Where: T = Main Block, Time
M = Sub-Block, Acre
B = Sub-Block, the Fertilizer Treatment
P = Sub-Block, the cultivar
δ = error
and $i = 1....m$, $j = 1....b$, $k = 1....t$,
$\delta_{ijk} = N(0,d_l)$

There was justification for using a covariance analysis with site and/or date as the control variable. It was not used because the level of variability attributable to each and to other causes was not clear. It seemed an unjustified level of sophistication.

One of the ongoing problems was estimating the level of sexual maturity in a crop. It was difficult to determine date of first flower as the sites were well separated and visited, at most, weekly; therefore, a maturity index was developed. Female flowers were classified as immature, value 1, maturing, value 3, and mature, value 5 (Figure 2).

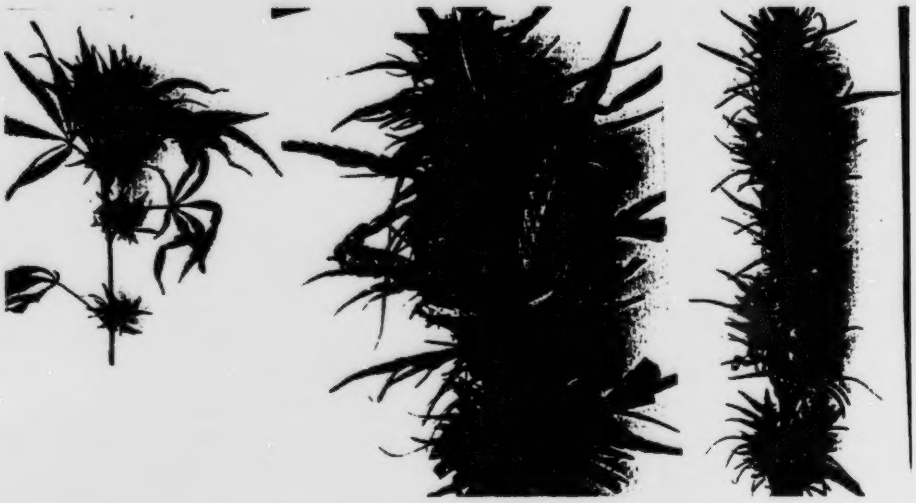


Figure 2. Pictured above are seed heads given as examples of the classification system used to develop the maturity index. The one on the left is immature given the value one. The one in the middle is classified as maturing given the value of three. The one on the right is classified as mature given the value five. The one on the right is from a different cultivar then the other two. It is Fasamo. It was very difficult to find a fully mature seed head in the other cultivars.

Harvesting for fibre was done toward the end of pollen release. This was about the first week of September. Mowers, conditioners, and discbines were all used to cut the crop.

Harvesting for grain was done after the industrial hemp had reached maturity, about the first through the last week of October. Grain was harvested using combine. The cutter bar was set as high as it would go, usually about 4 ½ to 5 feet off the ground.

The effect and feasibility of field retting was checked. This was done by leaving the harvested stock in the field to ret[2]. The time in the field ranged from 4 to 6 weeks or so to near 9 weeks.

---

[2] Retting is the most commonly recommended process used to ease the separation of fibre from stock. It is a partial rotting of the stock. The process to be used here is called field or dew retting. It consists of leaving the stock in the field for about four weeks or until the fibre separates easily from the stock. The length of time depends to some extent on the amount of moisture and the ambient temperature. Also it is necessary to turn the stocks at least once probably twice and maybe more depending on the weather conditions. The more sun light the more turning that is required.

THC samples were collected prior to harvest. The THC tests were performed by the Research and Productivity Council in Fredericton. Leaf sample, soil samples and samples of infected industrial hemp material were collected and taken to the NB Agriculture Soils Laboratory in Fredericton for analysis.

From time to time samples of diseased plant material were collected and taken to the NB Ag. Plant Pathology Laboratory for analysis. Yield samples were collected before harvest of fibre and seed. Either quarter metre square or half metre square areas in each treatment in each fibre and grain cultivar at each farm were sampled to provide data to calculate the yield. Entry point into the field, for each sample was selected at random, the area measured and all plants removed for the fibre yield or seed bearing area removed for the grain yield. The samples were taken to NB Ag. where they were dried and weighed.

Results

Physical and Biological Parameters. Sites L, O and W had markedly lower Phosphorous levels then other sites. L, O and S had lower potassium levels then the other sites. L, O and W had poorer growth then other sites; however it was not likely a soil's only problem.

Three of the sites had before plowing and after plowing samples collected. There were a number of large differences in the data for the two sets. This does create some problems in identifying causes and does suggest reason for the marked difference in growth between areas in the same site and treatment (Table 3).

The percent germination for the cultivars was good for Uniko - B, Fedora 19 and Felina 34. However, the Fasamo was a little on the low side (Table 4). This low reported germination rate, 82%, was probably a high estimate at the time of planting because it was done five months before planting, i.e. in January 1999.

Rainfall was very low through much of the summer. While it did improve in August it was still on the low side. The rain fall and poor performance of the crop through the first 60 days was discouraging and led to poor record keeping by the site operators from August on (Table 5).

The rainfall high for the period planting through to the end of July was 147 mm at site B. That probably represents a minimum level as growth was adequate and better then the other sites which are receiving less rain had poorer growth. In all cases growth did pick up with the increase in moisture in August.

Table 3. Results from soil analysis samples taken at the time of planting. Duplicate samples consist of one taken before plowing and one taken after plowing

Site	Organic Matter (%)	pH	CEC Meq/100g	Phosphorus P (ppm)	Potassium K (ppm)	Calcium Ca (ppm)	Magnesium Mg (ppm)	Copper Cu (ppm)
B1	---------	6	16.9	94 H+	234 H+	1118 H+	82 M	---------
B2	---------	6	15.7	122 H+	209 H+	1060 M+	88 M	1.8
H	---------	7	16.5	94 H+	30 L	1774 H	134 M+	1.7
J1	2.5	6	15.4	114 H+	136 H+	1497 H	38 L	---------
J2	3.2	6	15.1	113 H+	174 H+	1159 M+	93 M+	---------
L	3	6	16.3	27 M	44 M	914 M+	93 M	---------
M	---------	6	14.5	189 H+	236 H+	1081 M+	150 H	3.8
O1	5	6	19.8	71 H	38 M	2032 H+	62 M	---------
O2	4.6	7	21.6	61 H	21 L	3099 H+	73 M	---------
R	2.9	6	14.6	115 H+	34 L	858 M	35 L	--------
S	---------	6	16.4	111 H+	63 M	1214 H+	122 M+	5.3
W	---------	6	19.9	27 M	265 H+	1991 H+	217 H+	1.5

Table 4. Percent germination of each of the cultivars used in the 1999 growth trials

Cultivar	(%) Germination
Uniko B	93%
Fedora 19	91%
Felina 34	89%
Fasamo	82%

Table 5. The date planted and rainfall for six of the nine sites

		Rainfall at Site					
		B	H	J	R	S	W
Date Planted		June 04/99	June 20/99	June 06/99	June 06/99	June 10/99	June 09/99
Period	June 4 - 21	6 mm		nil	nil	----	----
	June 22 - 30	33 mm	nil	9 mm	9 mm	27 mm	nil
	July 1 - 9	10 mm	nil	28 mm	28 mm	12 mm	nil
	July 10 - 22	74 mm	nil	32 mm	32 mm	65 mm	nil
	July 22 - 31	24 mm	first rain	34 mm	34 mm	18 mm	nil
	August 1 - 7	11 mm	----	12 mm	12 mm	----	nil
	August 8 - 14	85 mm	----	----	----	6 mm	----
	August 15 - 31	13 mm	----	----	----	----	----
	Sept. 1 - 12	7 mm	----	----	----	65 mm	----
	Sept 11 - 18	98 mm	----	----	----	----	----
	Sept 19 - 30	-------	----	----	----	----	----
	Oct 1 - 9	9 mm	----	----	----	----	----
	Oct 10 - 18	50 mm	----	----	----	----	----

Compaction: A four way analysis of variance including rolled verses not rolled as one of the levels was performed on the data collected at three of the sites. All levels and interactions were statistically significant and that includes rolled verses not rolled with the exception of cultivar, fertilizer by rolled at site O (Table 6). Thus compaction does have an effect.

Unfortunately the effect is not straightforward. That is site B was the mirror image of sites R and S. It is worth noting here that all three sites produced commercially viable grain crops and that site R used conventional fertilizers and site S organic fertilizer.

Table 6. Summary of the four way ANOVA, three sites including rolled and not rolled

	Site					
	B		O		R	
Source	Degrees of Freedom	Absolute Value of F	Degrees of Freedom	Absolute Value of F	Degrees of Freedom	Absolute Value of F
Date	7	59.3	6	164.7	7	103.7
Cultivar	3	83.8	3	243.5	3	136.9
Fertilizer	3	26	3	105.2	3	170.6
Rolled	1	179.7	1	128.4	1	99.4
Date by Cultivar	21	31	18	67.4	21	31.3
Date by Fertilizer	21	30.6	18	58.8	21	31.2
Date by Rolled	7	52.2	6	82.4	7	8.9
Cultivar by Fertilizer	9	17.2	9	22.9	9	26.6
Cultivar By Rolled	3	103.4	3	11.8	3	484.4
Fertilizer by Rolled	3	60.3	3	63.7	3	104.2
Date, Cultivar by Fertilizer	63	12.2	54	24.9	63	12.3
Date Cultivar by Rolled	21	12.1	18	25	21	12.2
Date Fertilizer by Rolled	21	39	18	59.7	21	33.6
Cultivar Fertilizer by Rolled	9	39.5	9	0.4	9	43.7
Date Cultivar Fertilizer by Rolled	63	16	63	25.6	63	12.5
Error	4083		3367		4085	

Note: F values statistically significant with the exception of cultivar, fertilizer by rolled

Specifically (Table 7), Fedora and Uniko both did better when rolled at site B while the not rolled set did better at sites R and S. As for that matter was true at sites O and J as well. In fact, everything at J did better when not rolled, it also had very low rainfall, so low that it impacted the other field crops heavily. There was no difference for Felina at O and Fasamo reversed itself between O and J. Felina and Fasamo did better when not rolled at site B but more poorly at site R and S (Table 7).

While there are notable differences in the number of plants per square metre between sites and between cultivars there was no apparent statistically significance to these differences. There were also large differences in plant counts within treatments which made it difficult to identify trends. The differences were often more then double the number between sample sites.

There is evidence for late emergence as the counts, without exception, were higher June 27th then they were June 20th and this for seed planted between June 4th and June 6th. There is also some evidence of self thinning as many of the counts for August 22 are lower then the counts for June 27th (Table 8). The late emergence was extreme at site H where many areas in the field had no plants visible July 18th, from planting June 20th, yet had a commercially viable crop by the end of the season.

Table 7. A comparison of growth over the entire season in rolled and not rolled areas for each cultivar at each site. Zero indicates that the rolled growth at that site was statistically significantly better then the not rolled growth at the 5% level. One indicates that the not rolled growth was statistically significantly better, all based on the paired sample t test.

	Site				
Cultivar	B	R	O	J	S
Fedora	0	1	1	1	1
Felina	1	0	0	1	0
Fasamo	1	0	0	----	0
Uniko	0	1	1	1	1

Table 8. The number of plants in a square metre. An area was selected at random in each of the fertilizer treatments counted and the mean calculated for a site and cultivar.

		Plant Count per metre squared as of				
		36696	36703		36759	
		Not Rolled	Rolled	Not Rolled	Rolled	Not Rolled
Cultivar	Site					
Fedora	B	134	162	154	120	162
	L	132	----	170	----	150
	O	172	204	190	296	150
	R	144	194	184	160	162
Felina	B	144	190	226	174	194
	L	140	----	186	----	182
	O	156	136	232	204	182
	R	122	196	138	172	184
Fasamo	B	124	144	206	98	150
	L	150	----	136	----	120
	O	176	214	212	132	144
	R	132	138	166	152	132
Uniko	B	152	226	170	166	170
	L	124	----	228	----	252
	O	170	270	294	206	220
	R	140	174	232	192	178

Disease. The *Botrytis cinerea* fungal problem identified by Schom in 1998 turned out to be a several different species problem in that the 1999 industrial hemp crop was susceptible to more then one fungal species. *Botrytis* was part of the complex but identified in a far smaller proportion of the plants in the 1999 trial than in the 1998 trial.

Specifically, *Sclerotinia (sp)* was identified in August. *Botrytis* was present in September but to a smaller extent than *Alternaria (sp)* on the necrotic plant material. Thus, the problem in the 1999 year was a more general susceptibility to fungus which led to the production of hollow seeds, that is the seeds maturing later in the season do not develop fully.

As of October 4 the percentage of plants within a cultivar suffering fungal attack ranged from 38 to 91 percent for Fedora 19, 36 to 70 percent for Felina 34, 4 to 18 percent for Fasamo and 2 to 31 percent for Uniko B. The cultivar differences were consistent from site to site and statistically significant at the 1% level. The differences between sites were not significant at the 5% level (Table 9). The net effect was that by the end of October there was stalk with no seed and the stock with seed remaining that had a portion which were hollow (Figure 3).

Lodging was a major problem. Figure 4 gives illustration to it and the fact that an industrial hemp stand may look excellent from the distance but up close and inside have problems.

Lodging occurred in a significant portion of the plants at sites M, H, B and R. A good portion of the lodging at site M was attributable to European corn borer infestation. However, an additional significant proportion was associated with weak stems and root system. The weak stems may well be a result of very rapid growth once rain did begin in August at least at sites H and R.

There was no lodging in the Fsamo cultivars at any of the sites.

Maturation. Based both on the 1999 experience and the literature the author had expected the cultivars to mature following a pattern similar to that observed last year therefore set the grain sampling schedule accordingly.

The hemp did not perform as expected. Sexual maturation depends on more then just daylength. There are, as one would expect, differences between cultivars and these differences are statistically significant at the 1% level (Table 10). There are also differences attributable not only to planting date but to local growing conditions.

Table 9. The percentage of plants in each cultivar at each site infected with fungus as of October 4, 1999

Site	Percentage of Cultivar Infected with Fungus			
	Fedora	Felina	Fasamo	Uniko
B	88	70	----	----
H	----	----	4	2
J	71	52	18	----
L	38	19	----	----
M	47	33	0	15
O	67	23	12	22
R	65	67	13	22
S	91	36	13	31
Mean**	66.7	42.9	10	18.4

** Statistically significantly different at greater than 1% level

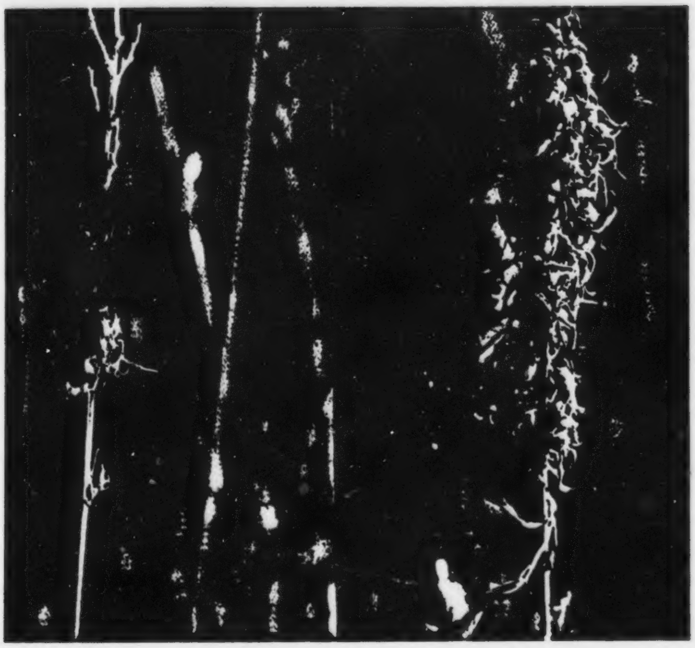


Figure 3. Examples of seed head suffering fungal attack. The picture on the right is of a head that is fully involved. The picture on the left is of a head that has lost all of its seed. At least ½ of the seed present on the head shown to the right are hollow, i.e. not fully formed.

This shows most clearly were the maturation index for Fasamo at sites H and O were lower then the other 4 sites recorded (Table 10). Site H was planted June 20th, i.e. about 2 weeks after the other sites; thus, its slower maturation can be accounted for by the late planting. Site O was planted June 6th thus its slow maturation can not be accounted for by planting date or emergence because the plants were up in synchrony with the other site; therefore, must be due to something else.

Another way of looking at the rate of sexual maturation is by comparing sampling times as all samples were taken when the cultivars at each site were at the same level of sexual maturation. Most of the information contained in table 11 is from site H some is included from other sites to provide a comparison.

Figure 4. Composite picture showing what looks to be a good stand of industrial hemp from a distance (top) and up close, lodging (left and right). The broken stalk on the right was attacked by European corn borer as were other stalks in the pictures. In addition, stalk is bent under the weight of the seed head.

Site H included four sets of volunteers identified by the area the pure cultivars were planted in 1998. The volunteers had all started to mature sexually well before July 15. The 1999 planting, June 20th began to mature about August 1 which was later than in the 1998 trials, but then again many of those plants did not emerge until after July 18th. Grain yield samples were taken up to a month earlier for the volunteers than 1999 planting.

Table 10. Maturity of the plants in each of the cultivars at each of the sites. The estimate of maturity is based on an index ranking level of maturation as 1, 3 or 5, see figure 2 for the key.

Site	Maturity Index			
	Fedora	Felina	Fasamo	Uniko
B	3.4	3	----	----
H[1]	----	----	3	1.3
J	2.9	2.7	3	----
L	2.7	----	----	----
M	4.1	3.6	5	1.6
O	3.5	2.6	5	1.3
R	2.5	2.3	5	2.5
S	2.7	3	5	2.3
Mean**	3.1	2.9	4.3	1.9

[1] Not included in the analysis because planted 2 weeks after others.

** Statistically significantly different at greater than 1% level

Table 11. A comparison of relevant dates when tasks were performed, i.e. when crops at different sites and/or planted at different times were at the same stage of development. The other sites used in the comparisons made here were all planted around June 4th. The volunteers were self seeded crosses from pure cultivars grown the previous year over wintering on the ground, germinating and growing.

			Sexual Maturation Reflected by Sampling times			
	Date Planted	First sign of Maturation at Site H	Seed Yield Site H	Date THC Sampled Site H		Date THC Sampled other sites ‘99
Cultivar				‘98	‘99	
Fedora	June 20/99	Aug. 1	36808	----	Sept 26	Sept 13
Felina	June 20/99	Aug. 1	Oct. 29	----	Sept 26	Sept 13
Fasamo	June 20/99	Aug. 1	Oct. 29	----	Sept 20	Sept 9
Uniko	June 20/99	Aug. 1	------	Sept 4	Sept 07	Sept 9
Uniko Cross	Volunteer	Before July 15	36802		Sept 07	----
Kompolti Cross	Volunteer	Before July 15	36802		----	----
Secuieni Cross	Volunteer	Before July 15	36802		Sept 07	----
Irene Cross	Volunteer	Before July 15	Sept. 26		Sept 17	----

The volunteer's plant material for THC tests was collected up to 19 days before the grain crop samples from the 1999 planting. That is the volunteer sexual maturation had reached the designated level to sample for grain at about the same time the fibre variety, Uniko B was ready to harvest for fibre. This was a week or so before the faster maturing Felina 34 and Fedora 19 planted in early June were ready to sample at other sites (Table 11).

Treatments and Yields (Fibre). All of the levels and interactions tested using the four way analysis of variance on data collected from sites B, L, J, O and R were highly statistically significant. Date, site, cultivar and fertilizer treatment as well as their interactions were associated with differences in growth as determined by height measured on a weekly and/or biweekly basis (Table 12).

One strip across the area Felina was planted in at site O was given a double shot of fertilizer. That is it got the equivalent of 1100 kg/ha as opposed to that next to it which got the equivalent of 550 kg/ha. The effect was to reduce the number of plants per square metre by about half and increase the height of those growing by 40 cm. (Table 13). While as indicated above similar differences were evident at randomly selected sample sites within a treatment none were juxtaposed to each other or demarcated by a straight line corresponding to fertilizer application as was the case here.

The reduced plant numbers was not likely due to increased nitrogen levels as no similar effect was noted at any of the trials were 250 kg/ha of urea was applied.

Biomass (fibre) yields were estimated two ways. One half metre squared areas selected at random were cleared of all plants. The total biomass was weighed. A sample from each of the weighed samples was bagged frozen and shipped to the lab in Fredericton for analysis. The procedures followed in Fredericton removed all of the water; thus the biomass yields reported here are zero percent water yields, i.e. are 15 to 20% below other estimates in the literature and up to 60% below what a standing crop might weigh as the dry matter in a standing crop accounts for less the 40% of the biomass (Table 14).

The estimates of fibre yields from sites that were not hand sampled was done using the correlation established between weight and height of the sampled areas. The correlation's coefficients were lower in the 1999 trial then they were in the 1998 trial; thus the estimates are made with less precision than expected. Further, growth was better, i.e. plants were taller, then at the sampled sites so some estimates are outside the range where the coefficients were developed which means they are subject to error; thus can only be viewed as number relative to each other then as actual estimates of biomass production.

Table 12. Summary of the results from the four way analysis of variance including sites B, L, J, O, & R. The variable examined is Height of a sample of plants. The procedures followed those of Guenther applied using MathCad 8.

Source of Variation	Degrees of Freedom	Absolute Value of F
Date	7	324.3
Site	4	61.7
Cultivar	3	31.6
Fertilizer	3	29.3
Date by Site	28	95.2
Date by Cultivar	21	133.3
Date by Fertilizer	21	135.6
Site by Cultivar	12	25.2
Site by Fertilizer	15	41.6
Cultivar by Fertilizer	15	42.8
Date Site by Cultivar	84	38.8
Date Site by Fertilizer	84	36.7
Site Cultivar by Fertilizer	36	24.4
Date Site Cultivar by Fertilizer	252	19.7
Error	10645	

Note: All F values are statistically significant

Table 13. A comparison of the growth characteristics of Felina in an area that had the correct level of fertilizer applied with one right next to it which had twice as much fertilizer applied. Measurements were taken September 13, 1999.

Treatment	Number of plants per metre squared	Height in centimetres
Single application of Fertilizer	228	113
Double application of Fertilizer	111	152

There was little or no difference between yields from the two urea treatments. In general; however, the addition of urea increased yield over straight fertilizer. Most sites high yields were in the range of 5 tons per acre (Table 15).

Site S did produce more then 8 tons per acre of the Uniko B in the plot treated with 10 tons of composted manure per acre, as did site W of Fedora 19 from the application of a similar amount of turkey manure (Table 16). The operator of site W applied that level to only a very small area of the field. The impact of that application can be seen in Figure 5. It should be noted that the 11.2 tons for site S and 12.6 tons for site W in table 16 were estimates using an estimator whose range ended at 8 tons; thus those numbers are optimistic with it only safe to say the yield was in excess of 8 tons per acre.

The inorganic composition of the cultivars depends to some extent on the materials available at a site. It is not surprising that percent dry matter in the stock might be a site specific property and was with a statistically significant difference at the 5% level, because all of the samples from a site were handled in the same manner. It is interesting and probably worth further investigation that elements proportions gave indications of site specific responses and manganese was statistically significant at the 7% level (Table 14). This is noteworthy given the small number of samples.

Table 14. Inorganic composition analysis of stock samples collected the week of August 22. The cultivars are symbolized as U (Uniko - B), D (Fedora 19), L (Felina 34) and S (Fasamo).

	Site											
	L				R				B			
Cultivar	U	D	L	S	U	D	L	S	U	D	L	S
Percent												
- Dry Matter	35	36	37	35	31	34	32	32	32	33	31	35
- Nitrogen	1	2	2	2.4	2.3	3	1.5	1.8	1.1	1.3	1.5	7.9
- Phosphorus	0	0.34	0	0.37	0.3	0.5	0.2	0.4	0.1	0.19	0.21	0.4
- Potassium	1	1.5	2	1.4	1.8	1.6	1.1	1.3	1.6	1.6	1.7	1.6
- Calcium	1	2	2	1.9	2.2	3	1.6	2.2	0.9	1.2	1.6	1.7
-Magnesium	0	0.46	0	0.55	0.2	0.3	0.2	0.3	0.2	0.26	0.28	0.4
- Sodium	0	0	---	----	0	0	0	0	----	0	----	0
ppm												
- Boron	17	29	27	25	27	25	18	27	14	17	21	18
- Copper	6	10	8	9	10	10	6	8	5	7	7	8
- Zinc	15	27	21	28	34	36	13	24	17	24	21	42
- Iron	46	108	78	121	81	138	51	84	72	116	159	110
-Manganese	31	84	50	102	275	308	125	174	72	116	159	149

Table 15. Yield of fibre and seed for five sites, four cultivars and all treatments. The fibre yields were calculated from weighed samples in most cases as were all of the grain yields. They were used to set up a regression analysis to predict weights from sites where weight samples were not collected.

		Cultivar Yield					
Site	Treatment	Fibre (Tons per Acre)			Seed (Pounds per Acre)		
		Fedora	Felina	Uniko	Fedora	Felina	Fasamo
B	None	2.3	1.9	0.84	224	334	428
	Fertilizer	5.7	4.3	2.2	167	441	781
	- Urea	5.8	6.1	5.1	425	228	1155
	- Double Urea	5.6	5.7	7.6	598	358	1164
J	None	2.2	1.6	2.7	149	237	----
	Fertilizer	5.2	5	5.9	84	190	----
	-Urea	4.9	4.7	7.4	77	162	----
	- Double Urea	4.1	3.6	6.6	----	----	----
L	None	2.3	3.1	4.3	----	----	170
	Fertilizer	4.5	4.6	5.9	----	----	338
	-Urea	6.4	5	2.9	----	-----	459
	- Double Urea	4.4	6.1	5.4	----	-----	-----
O	None	2.6	4	4	317	—	—
	Fertilizer	4.7	3.5	4.3	332	----	-----
	-Urea	7.4	2.4	3.5	574	—	----
	- Double Urea	6.3	2.1	5.1	490	—	----
R	None	2	2.5	1.6	160	251	267
	Fertilizer	7.1	4.9	1.4	118	112	1413
	-Urea	5.3	4.7	3.9	-----	130	1005
	- Double Urea	5.5	5.8	3.8	-----	195	1782

Table 16. Yield of fibre and seed for four sites, four cultivars and all treatments. The fibre yields were calculated using the data from the regression analysis done using the data from the other sites. The grain yields were based on weighed samples. All weights estimated at over 8 tons were beyond the range of the data used to calculate the regression line; therefore, can only be taken to be weights in excess of 8 tons, not the number estimated. They are presented to give relative differences one to another.

		Cultivar Yield					
Site	Treatment	Fibre (Tons per Acre)			Seed (Pounds per Acre)		
		Fedora	Felina	Uniko	Fedora	Felina	Fasamo
H	None	4.6	4.3	1.7	541.8	595.7	----
	Fertilizer	12.4	13.2	10.4	468.9	770.8	917.2
	-Urea	11.5	12.2	10.1	492.4	675.2	906.2
	-Double Urea	10.5	11.1	11.3	359.8	865.2	1209.5
M	None	8.9	6.9	8.1	----	----	823.7
	Fertilizer	9.5	6.8	10.4	----	----	965.3
	Fertilizer	11.4	11.1	6.6	----	----	1066.1
S	None	8.1	11.9	6.1	----	----	392
	Manure	11.2	16.4	12.1	----	----	660
W	None	2.1	2.6	1862	248	157	-----
	Manure	12.6	2.6	1744	748	748	-----

Figure 5. The photograph gives a prospective on the impact that a number of factors can have on size of industrial hemp plants. The hemp, Fedora, on the right hand side of the picture was planted in the area the turkey manure was dumped before it was spread. The size of the plants in the middle of the picture illustrate the impact turkey manure applied at the experimental design level. The tall plants in the upper left are Uniko. They are growing just down hill from pond thus got much more water then other areas of the field.

The percentage long fibre from a sample of material taken late in the trial gave well over 30% long fibre present in Fedora, Felina, and Uniko and 24% or so in Fasamo. The long fibre content was high for two reasons, first it was from samples of plant material collected late and second it is based on dry weights with zero percent moisture.

Overall yields were down in these trials because of the low rainfall (Table 5). When the 1998 yields are converted to tons per acre (there is an error in the caption of the table in the 1998 report which gives what should be kg per half acre as pounds per acre) the maximums are in the range of 9 tons per acre, much above what was calculated here from the hand samples. The impact can well illustrated by comparing the 1998 and 1999 growth of Uniko B at site H. While the final mean heights of the crop were similar there was no growth to speak of between planting June 20th, 1999 and July 16, 1999 (Table 17).

Table 17. A comparison of the industrial hemp cultivar Uniko B growth in the 1998 and 1999 trials at site H. All measurements are in inches.

	1998 Hemp Growth Trial			1999 Hemp Growth Trial		
Date Planted	35967			36328		
		Date Sampled			Date Sampled	
		July 16/98	Aug 28/98		July 18/99	Sept 7/99
	Treatment			Treatment		
	None	7.38	61.9	None	0	34.4
	Fertilizer	10	60.7	Fertilizer	15	70.5
	Doubled	17.1	74	Plus Urea	0	75.5

Given an additional 10 days, i.e. until September 7 the 1999 Uniko B crop did match the 1998 crop in height but not yield (Table 18). The number of plants per unit area was much reduced in 1999 over 1998. There was considerable lodging.

Treatments and Yields (Grain). Grain yields of 600 lb. per acre or greater were recorded at 5 sites. They were M, B, R, S, and W (Tables 15 and 16). All grain yields were based on hand harvested one half metre plots. Both sites S and W produced to this level growing in areas where 10 tons or so of manure per acre had been applied (Table 16). The site W grain was from the same small stand of Fedora which gave good fibre yields. The other sites all got their yields from Fasamo treated with fertilizer plus urea with the exception of site M which used only the fertilizer (Table 16).

Table 18. A comparison of the 1999 crop and the self-seeded volunteers from last year's crop. The volunteers are designated by maternal line, i.e. the plants were growing where that cultivar was planted last year, the assumption being that most seed falls near were it grew. The treatments for the 1999 year were: 1) no treatment, 2) fertilizer, 3) fertilizer plus one shot of urea, 4) fertilizer plus two shots of urea. The treatments for the volunteers were from last year in order 1 through 3, no fertilizer, fertilizer double load of fertilizer. All of the volunteers were treated with manure and urea in the spring 1999.

		Strain							
		Fedora	Felina	Fasamo	Uniko	Kompolti Cross	Secuieni Cross	Uniko Cross	Irene Cross
Date Planted		June 20/99				Self seeded fall '98			
Date Emerged		After July				Before June 2nd			
Plants per metre sq.		75	75	104	—	4	56	60	124
mean Height June 17, 1999		—	—	—	—	15.4 in	24.7 in	22 in	22.3
Mean Height July 18		—	—	—	15 in	55 in	52 in	52 in	35 in
Tons Fibre per acre	Treat-ment								
	1	2.2	1.6	—	2.7	—	3.3	7.9	—
	2	5.2	5	—	5	—	4.5	13.9	—
	3	4.9	4.7	—	7.4	—	6.5	13.2	—
	4	4.1	3.6	—	6.6	—	12.9	12.4	—
Lb. Seed per acre	Treat-ment								
	1	541	595	0	—	2034	541	1061	933
	2	468	770	917	—	2163	668	1048	929
	3	492	675	906	—	—	1262	—	1517
	4	359	865	1209	—	—	—	—	737

The Fasamo seemed to adapt to the drought conditions by growing very slowly initially. It grew rapidly once it got rain. This rain came largely at or just after maturation. The seed producing area of Fasamo at sites suffering early drought often accounted for 60% of the total height of the plant. This is illustrated in Figure 6.

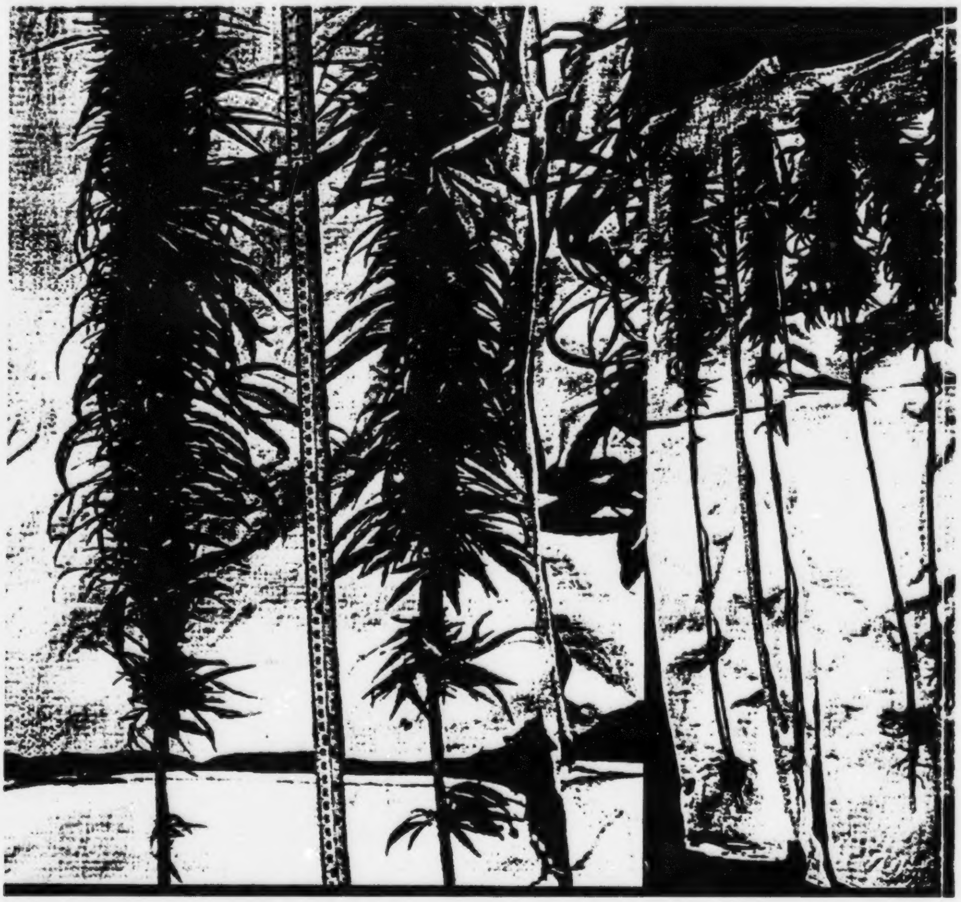
Volunteers. The volunteer's fibre production was estimated and again the estimate fall outside the rang of the estimator so are optimistic (Table 18). From similar height stands in the 1998 trial (converting to same units, see above) the yields were of the order of 8.5 to 9 tons per acre which is likely what these yields equal. Further there was no lodging among the volunteers. Though they did reach a height of 55 in by July 18th, there 1998 parents were 10 to 17 inches July 16 planted June 22 1998 (Table 17) their final yields of fibre were similar to the best of 1998. This may be accounted for in part by the fact that they had started to mature sexually well before the 18th of July and received little moisture through July.

Their seed production was remarkable. The Kompolti cross produced on the order of 2,000 pounds of seed per acre and this from a plant density of 4 plants per metre squared. The Uniko cross grain production was on the order of 1,000 pounds per acre and the Secuieni cross on the order of 1,200 pounds per acre. The Irene cross produced 1,500 pounds per acre and this from a stand that was not tall but did have a higher density of plants then the others (Table 18) which is interesting because the Irene parents did not.

One peculiar and unexplained observation deserves mention. Both Uniko and Kompolti were planted at two sites within the one and one half acre grown in 1998. The second planting was in manure. The Kompolti emerged about as well as the Kompolti reported above. It did not grow as well. The Uniko from self seeding at the manure site was in every way comparable to the Kompolti with poor germination and growth. It was very different then the Uniko cross described above.

THC Levels. No pattern was discernable in the THC results. The most southerly site in the trial, M, had a low THC level while more northerly sites such as B and J had higher levels. The parent stock of the Uniko cross in this year's trial was over the 0.3 % last year (Schom, 1998) while it was under this year (Table 19). Both the Irene cross and the Secuieni cross were high in 1999 (Table 19) as were their parents in 1998 (Schom, 1998).

Figure 6. Examples of Fasamo plants with relatively short stock and long seedhead.



The seedheads on a number of plants accounted for 60% of the above ground height. Further the photos illustrate the relatively small size of the roots. The tape measure gives a reference point both as to size and position of plants as it was not moved to take the close up. The mean height of the plants in the area these were taken from was 87.5 cm.

Table 19. Table summarizing THC results from sites growing the same cultivar in both years and the volunteers plus four other sites for comparison.

				1998 Trial		1999 Trial		
Strain	Site	# of plants sampled		Sample Date	THC	Sample Date	THC	Comment
		'98	'99					
Uniko - B	B	30	30	Sept 04	0.3	Sept 08	0.439	
	M	30	30	Sept 13	0.3	Sept 09	0.099	
	L		30			Sept 08	0.07	
	J		30			Sept 08	0.167	
	H	30	30	Sept 04	0.4	Sept 07	0.132	
			1			36808	0.056	Large Fungus
			1			36808	0.029	Large Mature
			1			36808	0.02	Large Mature
			1			36808	0.037	Large Mature
			1			36808	0.498	Medium, little Fungus
			1			36808	0.024	Medium Fungus
			1			36808	0.127	Small no Fungus
			1			36808	0.017	Small Mature Fungus
			1			36808	0.02	Large Fungus
			1			36808	0.03	Small Fungus
			10			36808	0.089	Mean of single plants
Uniko Cross			30			Sept 07	0.243	
Irene			30	36799	1.5			
Irene Cross			30			Sept 17	0.802	
Secuieni - 1			30	36799	1.7			
Secuieni Cross			30			Sept 07	0.845	

In addition, to the normal samples collected for the analysis individual Uniko - B plants were collected and analyzed. The 10 plants were collected at random from a one half metre square area chosen at random in the Uniko - B plot at site H. The individual plants THC levels ranged from 0.017 through 0.127 to a high of 0.498. The two plants with the higher THC levels appeared to have less fungus and be less mature than the others (Table 19).

Discussion

Agronomics. Interpreting growth data is always a challenge in particular with industrial hemp because the genetic variability is so high. A number of the cultivars on the market are the result of crosses. Uniko - B, for example, is marketed as an F_2 (second filial generation) (Bocsa and Kraus, 1997). An F_2, genetically speaking, is the most variable generation possible resulting from any set of crosses.

Soil composition is variable with differences from sample to sample (Table 3). Whether these differences are the result of plowing or because samples were taken from different parts of the same field is not clear. At any rate emergence, growth and yield vary from area to area within the same treatment. However, as the relative differences in height within a treatment seem to remain proportional between treatments it seems most likely that the differences between treatments are soil related rather then plant related.

Another way of putting it is this. The industrial hemp has tremendous innate plasticity when it comes to growth. A plant will grow as conditions allow. If the fertility of the soil and/or compaction will permit only a little growth the hemp plant will be short producing only a few seeds. If fertility is good and soil loose enough this same hemp plant will grow big and produce a lot of seed. The root of the hemp does not seem to be very aggressive (Schom, 1998).

The plasticity and variability in the genetic component does inject a very large source of variability into any hemp study which must be dealt with. Here it was dealt with by colleting a very large number of individual measurements.

Having stated that it does mean that the significant differences that repeat from site to site and correlate with treatments are very likely robust plant responses to the challenge being applied rather then variability present in the plants themselves.

The plants seem tolerant of large doses of nitrogen. That is there was very little difference between the plants from the two levels of nitrogen treatment, an observation that corresponds to that reported by Scheifele (1999a). Nitrogen seems to be eliminated as a cause of the reported (Schom, 1998) reduction in performance associated with the highest level of fertilizer applied. Although not necessarily as the added high levels of nitrogen in this study were applied after emergence and the effect discussed here would appear to be an emergence effect. That leaves phosphorous or potassium as the more likely culprits in the reduced numbers mystery. Here the reference is to the response observed to a double dose of fertilizer in this year's trials (Table 13). Something cut the number of plants emerging in half with the most likely causes either phosphorous or potassium if the argument about nitrogen holds.

Table 13 raises another question as well. That is what caused the plants in the doubled fertilizer treatment to grow taller? Was it the fertilizer? Was it the smaller number of plants per unit area? The latter would seem likely to be part of the answer as it does appear to have had the same kind of impact in 1998 (Schom 1998).

Another element that seemed to have an impact in the 1998 trial was compaction. Growth at sites that used planting systems that rolled the seed in was poorer than that associated with other planting systems (Schom 1998). This year all sites were planted using seed drills of one type or another. One half of each of the cultivars at a number of sites was rolled, as is standard practice, with the other half left unrolled.

There did seem to be a cultivar specific response with both the field notes and the statistical analysis corresponding in general. There was a cultivar specific response. Felina 34 and Fasamo performed better both initially and throughout the trial in the unrolled areas at the majority of sites. While the Fedora 19 and Uniko - B both seemed to do better when rolled at least in the majority of the sites (Table 7). There were exceptions in that site B responses were the mirror image of the others. Site B had more moisture and differed in other ways also.

In particular the Uniko - B response must be set aside because the soil quality deteriorated over the width of the row the Uniko - B was grown in. That edge of the field was far rockier with what appeared to be poorer quality soil and it got worse as the outer edge of the plot was approached. The operator reports poor growth from other crops grown there also.

Fibre and grain production seem to have different moisture requirements. Even though at the majority of sites the plants had 20 days plus or minus longer to grow in the 1999 trial they did not outperform those in the 1998 trial. If sites do not have the water table near the surface as site D and P in last year's trials did (Schom 1998) then interpolating from this year's data (Table 5) implies that at least 150 mm of rain is required in the first 8 weeks to allow for growth. Even that amount was not sufficient to allow for performance that matched the 1998 fibre data.

The moisture issue is further complicated by the fact that lodging was a far more severe problem this year at the sites where growth was best than it was last year. This lodging cannot be attributed to European corn borer at all sites as it was at site M.

Conditions at site H, which was planted on the same date in 1998 and 1999 may provide a part solution. While there was some lodging in 1998 it was nowhere nearly as severe in the year to year control, Uniko - B as it was in 1999. Site H had virtually no rain from planting through July 22nd. It also had virtually no emergence and growth. However, once it did start to rain there was compensatory growth leading to a crop which reach commercially viable yields, but also had much more lodging then in 1998 which produced more fibre.

While the other sites did emerge and did grow some growth, including that at site B was not as rapid as last year through July 22nd or so. A characteristic of compensatory growth may be increased lodging.

Grain production did not suffer. It would seem and this does correspond to results from Saskatchewan where irrigation was used (Prytyk, 1999). Enough moisture to get good germination is needed and that moisture is also needed at the time of sexual maturation. It is necessary from sexual maturation to seed set but in lesser quantities. This would certainly seem to be the case for Fasamo and the volunteers. However, a note of caution should be added because enough moisture to start the maturation process with little to follow may lead to a drought induced calcium deficiency as was reported by Schom 1998.

Disease. Fungal infection was present in the maturing grain this year as it was last year. The snap shots (time and place plants were sampled) taken this year gave a different picture than last year. Last year the *Botrytis cinerea* was the predominate fungus. It was present at a far lower level this year. In fact the seedheads from Fedora 19, Felina 34 and Uniko - B were attacked at one time or another by *Scleratinium* (sp), *Alternaria* (sp) with some *Botrytis cinerea* present. The seed bracts were infected with *Alternaria* (sp).

The onset and progress of fungal attack was slower this year than last. That is probably in part because there was less concentrated rain early in September in 1999 than there was in 1998. However, the net effect was the same, a good portion of the seed produced by Uniko - B, Felina 19 and Fedora 34 were hollow, did not mature completely and the overall yields were low (Tables 15 and 16). However, the Fasamo averaged about 10% of the plants with fungal infection (range zero to eighteen percent) (Table 9). The yields were good, as high as 1, 782 pounds per acre (Table 15 and 16).

Insect problems were minimal with one glaring exception. The European corn borer caused significant damage at Site M. In fact, the combination of lodging, in general, and European core borer caused lodging was so great that yield measurements were not taken at the time the other sites were measured. The data from early August was and results indicate an acceptable crop at that point. Thus, an operator would be wise to monitor the crop and harvest it at the first signs lodging which might be a threat to the crop.

The non-corn borer caused lodging may well have been an indirect result of the insect caused problem at site M. Some evidence from last year's trial could be interpreted to mean that the plants tend to support one another. When they lose this support they lodge (Schom, 1998). Thus, the borer caused lodging removed some of the support which meant that the uninfected plants did not have the support they needed to resist the impact of wind and rain.

Fasamo had no lodging or European corn borer problems. That may be because the stalk was just to small, at the time the attacks took place to provide a suitable substrate for the European corn borer. Further Fasamo had little or no fungal problems either.

There was some evidence of pests causing leaf damage but never sufficient to warrant investigation as it always passed. Insects were present this year as they were last year. That included bees, black flies, mosquitoes and sucking pests, lots of aphids, etc. They did not seem to have any impact on the industrial hemp. They did have impact on field workers.

Sexual Maturation. The assumption that sexual maturation was controlled by day length alone proved incorrect. There was evidence from the previous year's trial that delayed planting delayed onset of sexual maturation. Plants at some sites might have begun maturing a little later than at other sites but the evidence was not strong (Schom, 1998).

The volunteers at site H began maturing early, before July 14th. They had been growing for sometime and had a mean height of 55 inches. Those planted in the 1999 year at sites with adequate moisture were about the same height. That is in contradistinction to the 1999 planting at site H, done June 20th which had a maximum height of 10 inches or so and large areas with no plants.

By July 14th the volunteers at site H and the 1999 planting at site B were maturing sexually. By July 25th at least 10% of the male plants were releasing pollen at both sites. The 1999 planting at site H was 15 inches high at a maximum. Pollen release was about 10% at site M also, but not at S or, to any great extent, at the other sites if at all.

Sites M, H and S are south of B. While sites J, L, R and O are north of B; therefore, it does not seem likely that the maturation differences is associated with latitude. Furthermore, site J which was less then 5 km away from site L matured more slowly than L. Thus, not only is there a photoperiod response component but the critical level depends on other factors. Some of the other factors might include physiological age rather then chronological age, rate of growth and/or release from water stress, i.e. rain following a period of drought. The latter would fit the observation made earlier that moisture at maturation increases seed yield.

Yield (Fibre). Given well tilled soil, moisture and fertilizer any piece of reasonable farm land in New Brunswick should be able to average 5 tons an acre of biomass. That is not to say it will be a uniform yield because industrial hemp is plastic and responds to conditions in its immediate vicinity.

It should be possible, given the right set of conditions, to see biomass yields close to 9 tons an acre on a regular basis. The right conditions include a well plowed, well disced field with conventional fertilizer (12 - 24 - 24) applied at 550 kg/ha and additional nitrogen in the range of 150 kg/ha of 46-0-0 applied 2 weeks or so after planting and enough moisture.

An organic regime that does the above, replacing the fertilizers with 10 tons of manure, preferably composted, per acre should achieve similar results. The application of manure plus urea does not match either of the other regimes.

Harvest time is critical not only from the point of view of fibre development but also from a disease and environmental response point of view. As plants age, go into senescence, they deposit lignin among the long fibres. Conventional wisdom states that leads to a decline in long fibre quality.

An alternate problem can be assessed by examining site M data. August 12 there was a good crop of fibre hemp in place. Table 16 gives yield estimates for M and other sites. M's was an August 12th figure. The other sites both in tables 15 and 16 are for the end of August or beginning of September. Pollen release had begun. Lodging was occurring, most severe in Fedora, next in Felina with some corn borer related in Uniko. It was a crop in trouble even though it looked excellent from the distance (Figure 4). It should have been harvested then.

It wasn't, which, of course, is one of the advantages of a research project. By the time regular harvest would have taken place lodging had increased to the point where it was not possible to get height measurements on the plants, too many of them were over.

To some extent the same was true of site H and B but on a different time line. The site operator is going to have to watch the crop. It should be harvested not only based on pollen release but also on basis of disease and other performance criterion like the beginning of either pest induced lodging or environmentally induced lodging.

Finally, the yield figures are for biomass. That means they include leaf, developing seed, in fact everything that was more then 3 inches above the ground. That means the long fibre present will be less than a 30% theoretical projection might indicate. On the other hand because these are zero moisture dry weights the yield is at least 15% better than other figures reported in the literature.

Yield (Grain). The grain yields do need to be viewed with caution. First, these were based on hand harvested samples, that means every seed was harvested. Combines often leave seed in the field, on average as much as 30%. So harvested yields will be lower. On the other hand these yields were calculated from seed with zero percent moisture so the field yield weight would be higher.

Harvesting time does present a problem also. The grain can be harvested when the seed is ripe but before moisture levels have fallen low enough. This gets a very high proportion of the seed; however, presents storage problems. The operator a site B followed this strategy, got literally every seed but had a severe heating problem during storage and early drying.

The heating problem can be avoided by waiting to harvest until moisture levels have declined (Moes, 1999). However, this means shattering has started. Hemp maturation occurs over time with the first flower seeds maturing before the last seed is even pollinated, in some instances. The early formed seeds are ready to depart long before the last seed. If the harvest is delayed until moisture content drops then a number of the early maturing seeds are on the ground.

The above argument, in the context of this study, applies only to Fasamo. The other acceptable cultivars were all susceptible to fungus. This "resistance" needs to be investigated. It does appear that there may be some genetic components present as the incidence of fungus was lower in the volunteers this year than in the current year's crop and or the volunteers' parent stock. Part of the resistance may be slower onset of senescence. This can be argued as follows.

The slower maturing Uniko - B had a lower incidence of fungal infection than the other two cultivars. The volunteers' seedheads seemed to have more green in their leaves than other cultivars at the same stage of seed maturation. The Fasamo leaflets were still green long after all of the seeds had hardened and shattering was occurring. Thus, the first area to investigate might be onset of senescence although some metabolite might be associated with the resistance also and might be identifiable.

Caution needs be exercised also because this is one year's data. Fasamo may not be as resistant as is implied here. That is given a year similar to last year Fasamo might not produce seed.

The yield of usable seed from Felina and Fedora will be lower than the yields given because a proportion of their harvested seed are hollow. Thus, even though some of the weights are high the likely usable proportion takes them down to the point where they are probably not commercially viable yields.

THC. Single plants here reported had a THC level of near 0.5% (Table 19). The incidence of plants over 0.3% in this small sample was 10%.

It does not take much thought to see how the inclusion of a few higher THC level plants in a sample would push the sample level over the 0.3% limit. Given that this, a small sample, did pick up one with a high level does imply that the frequency might be quite high even in the range of the 10% implied by these data or even more. This implication does get circumstantial support from the 30 plant, required sample, which had a THC of 0.132, i.e. higher then the average of the 10 sample set which was 0.089.

Conclusions

A number of conclusions can be drawn from the work to date:

- Nitrogen applied does not need to exceed 100 to 120 kg/ha.
- Attention does need to be paid to level of phosphorous and potassium applied as one or the other or both may be toxic to some plants at some level. This need further investigation.
- There seemed to be a cultivar specific response to rolling that deserves further investigation. However, at this point, as it costs more to roll than not to roll it would seem better not to roll.
- Fibre and grain production seem to have different moisture requirements. Fibre seems to require higher levels right from the start. Grain production seems to require moisture at germination and then again at sexual maturation.
- Last year's snap shot of fungal attack identified *Botrytis cinerea* only. This years included not only *Botrytis* but also *Scleratinium* (sp), and *Alternaria* (sp). The second two were probably present last year also. The net result was the same, much reduced seed crop in three of the cultivars. Fasamo was resistant.
- Sexual maturation depends not only on daylength but other factors as well.

- Biomass yields in excess of 5 tons per acre should be achieved so long as attention is paid to providing a good seed bed, enough fertility and enough moisture is available.

- Biomass yields on the order of 9 tons per acre are realizable on a regular basis from New Brunswick farms with good soil, fertilizer and moisture.

- Harvest time for fibre depends not only on time of pollen release but also on the biological status of the crop, i.e. is lodging beginning, no matter what the cause.

- Grain yields for Fasamo were at a commercial level at five of the nine sites.

- Grain yields for Felina and Fedora were all at a level that when hollow seed was taken into account they were uneconomic.

- Industrial hemp cultivars need to be cleaned up. That is the genetic variability must be reduced within a cultivar before more precise estimates can be made as to the potential for yield than can be made today.

Further, multi-acre trials at many locations in the province have provided about as much information as can gained from them in a cost effective manner. It is probably time to focus on small plot trials with particular attention paid to day to day changes, that is the sites probably need to be assessed daily. Other of the relevant questions can probably be best addressed in growth chambers and on the lab bench.

In particular, emphasis should be placed:

- on root development, its interaction with soil, inorganic elements and the response to other hemp plant roots to determine both the responses of individuals and/or whether there is a generalized response at all. A number of responses recorded could be accounted for by having different genetic sets of plants emerge under different sets of conditions, i.e. a specific genotype by environment interaction leading to differential emergence.

- on cannabinoid level and development as controlling it will probably be critical to meeting government guideline.

- on reducing the genetic variability in cultivars. It appears that the genetic potential of a seed from the same cultivar may, within the same environment, have 2 to 3 times or even more potential for growth and yield as another seed in the same lot. The variability among individuals within a cultivar is more what one would expect from a wild population than a domesticated one.

Acknowledgments

This project came to fruition because a number of people helped. First and foremost are the farmers who grew the crop. Many other people helped putting far more hours than they were required to. The NB Ag. group working out of Bathurst deserve special commendation. Without their assistance this would not have been the success it was. Further the Ag. NB specialists provided just exactly the kind of backup needed to identify causes and for that I thank them very much. Finally a special thanks is due the people in the soils lab for giving me the analysis they did.

References

Bocsa, I and Karus, M., 1997. The cultivation of Hemp. Hemptech, Sebastopol, California.

Clarke, R.C., 1981. Marijuana Botany, Ronin Publishing, Berkeley, Ca.

Gehl, D., 1995. Summary of Hemp Research in Canada. AAFC, Indian Head, SK.

Health Canada, 1997. Summary Report on Hemp Research Licenses (1995-1997), Health Canada Web Site.

Hunstberger, D.V., 1967. Elements of Statistical Inference. Allyn and Bacon, Boston Mass.

Kolander, Cheryl, 1995. Hemp for Textiles. MAMA D.O.C. Inc., Portland Oregon.

Prytyk, 1999. Personal Communication.

Scheifele, G., 1999a. 1999 Agronomic Field Studies to Determine Factors Effecting Hemp Stalk Production in Northern Ontario., Kemptville College, Thunder Bay, ON.

Scheifele, G., 1999b. 1999 Agronomic Field Studies to Determine Factors Effecting Hemp Grain Production in Northern Ontario., Kemptville College, Thunder Bay, ON.

Schom, C.B. 1998. Hemp Growth Trials - New Brunswick 1998. *Adaptive Research Reports*. **20:** 9-59, NB Department of Agriculture and Rural Development, Fredericton, NB.

Twomey, S., 1995, The re-emergence of fibre hemp in Canada . Global Biodiversity 5 (4).

PROFITABLE PRODUCTION OF SPECIALTY MUSHROOMS ON SUBSTRATES AVAILABLE IN NEW BRUNSWICK

PRODUCTION RENTABLE DE CHAMPIGNONS SPÉCIAUX DANS DES SUBSTRATS ACCESSIBLES AU NOUVEAU-BRUNSWICK

David Boyle[1]

Partner / Partenaire : Maritime MicroBiologicals

Abstract: A method for growing specialty mushrooms on sterilized, supplemented maple or birch sawdust from N.B. sawmills was developed. Emphasis was placed on shiitake (*Lentinus edodes*) since the market size and price for this mushroom is good. After considerable experimentation with medium composition and growing conditions, high yields were attained. However, variability in yield remains a problem. Modifications of the method were also used to produce maitake (*Grifola frondosa*), oyster mushroom (*Pleurotus ostreatus, P. citrinopileatus*), lion's mane (*Hericium corraloides)* and reishi (*Ganoderma lucidum*). Interest in all of these specialty mushrooms is rising due to their good flavor and/or nutriceutical value.

Résumé : Une méthode a été mise au point pour cultiver des champignons spéciaux dans une sciure stérilisée d'érable ou de bouleau provenant de scieries du Nouveau-Brunswick et enrichie de suppléments. La culture touchait principalement le shiitake (*Lentinus edodes*), puisque la taille du marché et les prix sont favorables pour ce champignon. Après de nombreux essais portant sur la composition du substrat et les conditions de croissance, on a obtenu de bons rendements. Toutefois, la variabilité du rendement constitue encore un problème. La méthode a été modifiée pour produire des polypores en touffe (*Grifola frondosa*), des pleurotes (*Pleurotus ostreatus, P. citrinopileatus*), des hydnes (*Hericium corraloides*) et des polypores lucides (*Ganoderma lucidum*). On s'intéresse davantage à ces champignons spéciaux à cause de leur saveur et de leurs propriétés nutraceutiques.

Introduction

The goal of this two year project has been to develop methods by which specialty mushrooms can be profitably produced on waste wood substrates that are available in New Brunswick. Specialty mushrooms have gained popularity in North America, this being attributable to their excellent flavour, and to their health benefits (see Stamets, 1993 for a review). The main focus during this project has been on shiitake (*Lentinus edodes*) since this mushroom has a good shelf life, commands a reasonably high price and has a very large market (at least globally). Some attention was also placed on maitake (*Grifola frondosa*) and a few other other wood-decaying species including various strains of oyster mushroom (*Pleurotus ostreatus, P. citrinopileatus), reishi (Ganoderma lucidum)*, and lion's mane mushroom (*Hericium coralloides*). The market size for oyster mushroom is comparable to that for shiitake, but the other species are mainly of interest as small volume, high price products. Some of them (reishi, maitake) are well known nutriceutical products (Royce 1996).

Emphasis was placed on species that could in theory grow on the abundant waste hard wood sawdust that is available in the province. The above-mentioned species are all saprophytes. As such, their cultivation will not endanger standing timber resources the way that cultivation of e.g. honey mushroom (*Armillariella mellea*, a well-known pathogen) might. We did not attempt to grow e.g. chanterelle (*Cantharellus cibarius*) or the boletes (e.g. *Boletus edulis*) since these are mycorrhizal, and have to be grown in symbiotic combination with living trees. Nor did we attempt cultivation of other species that are currently being marketed as specialty mushrooms such as portobello or cremini. These are actually the same species as the button mushroom (*Agaricus bisporus*) and like the button mushroom, are grown using a substrate (composted manure) and equipment that is entirely different from what is required to grow shiitake and the species dealt with here.

---

[1] Maritime MicroBiologicals, 379 Saunders St., Fredericton, NB E3B 1N9

There are now between 75 and 100 specialty mushroom producers in Canada, most being in Ontario and British Colombia (Rinker and Chalmers 1998). In contrast, prior to the start of this project, there were no producers in New Brunswick. A goal of this project was to adapt some of the technology that is being used elsewhere so it was applicable here. There are now at least two NB groups growing shiitake on sawdust, although unfortunately, in one of these cases the grower is importing the processed sawdust from the U.S. There are also some people producing shiitake and other species on logs in an outdoor setting. It seems likely that the number of specialty mushroom growers will increase in response to the rising demand for the mushrooms.

Materials and Methods

Microbial Cultures and Culture Conditions. Except for strain 4000, the *Lentinus edodes* strains KO, WSB, 602, Wil were from Maritime MicroBiologicals' culture collection. Strain 4000 was isolated from a shiitake block provided by a grower. The maitake (*Grifola frondosa*) strains XXX and YYY were isolated from a large mushroom that was growing near the Catherdral in Fredericton. Other maitake stains (DAOM 195185, 10235, and 21005 were obtained from the Canadian Collection of Fungal Cultures, Ottawa. *Ganoderma lucidum, Pleurotus ostreatu* and *P. citrinopileatus* were from Maritime MicroBiologicals collection. In all cases, working cultures were grown at 25 °C on mycological growth medium (MGM) that contained 15 g malt extract and 4 g yeast extract per liter of distilled water. For solid cultures, 16 g per liter L agar was added. For liquid cultures 250 mL flasks containing 50 mL of MGM were inoculated with ca 50 1mm^3 pieces cut from colonies growing on MGM agar. The flasks were shaken at 60 rpm at 25°C.

Percent Moisture and Water Potential. The fresh weight of samples was measured and they were then dried in a microwave oven operated at low power. They were dried until their weight did not change by more than 2% in 3 minutes. The weight lost was assumed to be water. The percent moisture was calculated as the wt of water per fresh wt of sample x 100 %.

The water potential (a measure of how available water is for microbial growth, Kramer, 1969) of the sawdust mixture was determined by dew point depression methods using a Wescor, Inc. (Logan UT) 33-T psychrometer with a C-52 chamber. Standard curves were prepared using KCL solutions. Results are expressed in MPa.

pH Measurement. Samples (5 g) were mixed with 8 mL of distilled water to give a slurry. After 10 min the pH was measured using an Orion model 801 pH meter.

Chemical Analysis. A composite sample of medium was taken after it was thoroughly mixed. Another composite sample was taken from the same medium after it had produced a crop of mushrooms in which the yield was about 400 g (fresh wt) per block. The two samples were analyzed by the NBDARD lab for the indicated nutrients.

Assessment of Mycelial Growth and Development. Radial growth rate was measured on malt agar medium by measuring the difference in colony diameters 1 and 5 days after inculation.

Mycelial growth on sawdust medium was measured as described by Boyle and Kropp (1992). In most cases, the subjective assay was used. For this, mycelial density was estimated on a scale of 0 (no growth) to 10 (complete colonization, sawdust no longer visible). In some cases respiratory activity was used as a measure of growth. For this, gas samples were withdrawn from the air over the substrate upon which the mycelium was growing using a gas-sampling syringe. The medium was contained in either mason jars equipped with serum stoppers for sampling purposes, or in sun-bags (see under block production, below). Where the bags were sampled, the hole from the needle was sealed with a small piece of tape. The amount of CO_2 and O_2 in the gas samples were measured by gas chromatography with a Carle model 5800 GC equipped with a TCD detector.

The type of growth was sometimes also qualitatively assessed. During shiitake growth, the block develops a highly textured, wrinkled surface. This is referred to as 'pop-corning'. The block surface also changes from white, to a dark brown. Both of these features have been reported to correlate with subsequent mushroom production (Donoghue and Denison 1996). We assessed popcorning and browning on 0 (no browning or popcorning) to 10 (substrate surface completely brown or popcorned) scales.

Spawn Production. Spawn was produced using a modification of the methods presented by Eliot (1995). The strains of interest were grown on both MGM and SM agar medium, the SM being used to confirm that the fungal culture was bacteria-free. The MGM cultures were then used to inoculate MGM liquid. After two weeks, 25 mL of the liquid culture was aseptically poured onto 250 mL of sterilized sawdust-based medium (shiitake, maitake, reishi) or millet-based medium (lion's mane, oyster mushrooms) contained in mason jars with foam plugs in their lids to allow gas exchange. After two additional weeks, 100 mL of this medium was used to inoculate 1500 mL of medium that had been autoclaved in sun bags. These were heat-sealed and mixed after 1 wk to spread the mycelium evenly through the mix. The bags were incubated at 25°C. Spawn was used 4 to 8 weeks after inoculation of the bags.

Substrates Used for Mushroom Block Production. Most tests were made using fresh maple sawdust (mix of hard and soft maple) from the hardwood mills in Stanley, Woodstock or Boistown N.B. On one occasion we used birch sawdust. Once we obtained oak sawdust from the Boistown mill and used it for testing maitake. Sawdust was stored under cover, and was generally used within two months of collection.

A variety of supplements were tested. The ones we tested are listed here with their % N in parenthesis: wheat bran (2.37%), white millet (1.84%), soy meal (7.76%), feather meal (13.6%), herring meal (11.5%) waste fish meal (6.4%). The first three of these were from Shur Gain Feeds 'n Needs, the forth from the Co-Op farm supply, and the last two from Corey Feeds.

Gypsum (CaSO4) was also usually added. This probably serves as a source of Ca, but may have other functions (Stamets 1993). This was obtained from Kingsclear Mushrooms. It was added at a rate of about 1 L per 100 L mix.

Vermiculite (medium grade) was also sometimes added. This was from Scotts Nursery. All of the above-mentioned suppliers are in or near Fredericton, N.B.

Tap water was used for block production. The amount of water and the other components varied. Unless stated otherwise, our basic formula contained 40 L of sawdust, 6 L of millet, 6 L of bran and 0.5 L of gypsum. (Modified from Stamets, 1993). Water was added to give a moisture content of 58%, after autoclaving.

Small-scale Test Systems. To compare growth on various media, 220 g (fresh weight) of the media with the various amendments were placed into 1L mason jars closed with lids with foam stoppers. These were autoclaved for 45 min at 121°C, cooled overnight, then inoculated with 1 tablespoon of spawn. After 6 weeks, they were assessed for growth, browning and popcorning. Also, the respiration rate was measured. For this, the lids were removed and sterile air was blown through the jars for 1 min to displace the CO_2. The lids were then replaced with a gas-tite lid equipped with a serum stopper. After four hours, gas samples were withdrawn and analysed for CO_2.

To assess the effect of moisture, 3 g of medium that had been dried at 60°C was placed into 30 mL vials. Water was added to give the indicated percent moisture. The vials were closed with loosely-fitting lids and autoclaved for 5 min. Weighing before and after autoclaving showed the vials did not loose or gain appreciable water. After autoclaving, the water potential of small samples of the medium from the vials were measured and the vials were inoculated. For this, discs of mycelium cut from the edge of colonies on a MGM plate were used. After 10 days, mycelial growth was subjectively assessed.

Preparation of Shiitake and Maitake 'Blocks'. For larger-scale production of mycelium-colonized substrate (referred to as 'blocks'), the various components were mixed thoroughly in a 200 L mixer. About 2.2 Kg was then distributed into type 2 polypropylene (autoclavable) bags ('Sun Bags') equipped with microporous breather patches (source, Unicorn Bags, TX). The bags were folded closed, and 6 were placed into fabricated metal boxes with loosely fitting lids. The boxes were autoclaved for 220 min at 121°C, cooled to 100 °C, and then re-autoclaved at 121°C for an additional 20 minutes. (In earlier tests, autoclave cycles as short as 120 minutes were used, but bacteria persisted in some of the bags. The longer, double autoclaving cycle ensured that all substrate was sterile).

After autoclaving, the boxes were cooled in a sterile room. The bags were removed from the boxes, opened under a stream of HEPA-filtered air and 50 mL spawn was added. The bags were heat sealed and manually mixed to distribute the spawn.

The bags were incubated at 25°C. About 2 cm of space was left around the bags since if they touched, mycelial growth was inhibited. Initially, the humidity in the room was high (70-100%) to minimize water loss from the bags. Later, it was found this was not important since water loss from the bag was not significant. The humidifiers were turned off.

Mushroom Production. 1. Shiitake. Our original intent was for commercial-scale testing of blocks to take place at Hope Mushroom Farm in Moncton. After sending them about 3000 blocks it became evident that they would/could not provide any quantitative data on block performance. (Nor would they pay for the blocks). Fortunately, we had kept blocks from many of the treatments so we produced the mushrooms in the growing room at Maritime MicroBiologicals.

This 12 ft x 12 ft room was maintained at 20 +/- 2°C using a thermostat that controlled an electric heater or air conditioner as required. The room was lit for 16 hrs by 2, 60 Watt incandescent bulbs and 2, 40 watt cool white fluorescent bulbs. A mist system (50 psi, ~ 10' diameter droplets) was controlled by a solenoid valve that came on 4 times per day, for 4 minutes each time. This thoroughly soaked the surface of the blocks and kept the humidity between 70 and 100%.

To promote mushroom formation, the plastic bags were removed from the blocks about 10 weeks after inoculation. Initially the blocks were placed directly onto shelves in the production room. In later experiments (see results) they were rinsed or soaked before moving them to the rooms. In some instances this was done with a mixture of bleach (40 mL, 5.25% hypochlorite) in 50 L of water, the mix being acidified to pH 4 with citrate. However, we became concerned that the hypochlorite might form chlorinated organic compounds that could be health hazards, so we returned to using just water.

In one experiment we injected water into the blocks instead of soaking them. For this, we used a 1/32" i.d., 12" long copper tube, connected via a needle valve to the water supply. The water flow was adjusted to 500 mL per minute and the copper tube was pushed into the middle of the block for about 2 minutes. For comparison, other blocks from the same production batch were soaked. Weighing these before and after soaking showed they absorbed about 1 L of water.

About 4 days after the blocks were moved into the production room mushrooms began to form and by day 7 they were mature. They were usually picked on day 7 or 8 at which time the gills were visible, but the edge of the cap was still in-rolled. At picking, the weight (and sometimes number) of mushrooms was recorded. They were also rated with respect to quality, and the amount of mould on the blocks was assessed. (Only weight data is presented in this report, but the other information is available on request).

The mushrooms appeared in 'flushes' (i.e. crops), each lasting a few days. Between flushes, the blocks were kept in the same room as the producing blocks, but were protected from direct misting with a plastic sheet. After 8-12 days, they were re-soaked to initiate the next flush. In some cases this was repeated 5 times but usually, due to space limitations just the first (usually largest) flush was collected. (It would probably have been better to have had the blocks at a lower temperature and humidity during the inter-flush period, but due to space limitations, this was not possible).

2. Maitake and Other Mushrooms. Many different conditions have been tested for maitake production, but to date, we have only succeeded in producing mushrooms using methods and conditions similar to those used for shiitake. The literature suggests that a lower temperature would be advantageous (Stamets 1993), but our grow room did not have this capacity. Testing is currently being done in a lower temperature environment, but the results will not be reported here. The other mushroom species were produced using methods that are not presented here.

Results

Assessment of Mycelial Growth in Small Scale Systems. 1. Shiitake and Maitake Strains. Five different shiitake strains were compared for growth on MGM medium. All grew at about 0.6 cm per day and showed similar morphology. When inoculated into mason jars containing the standard medium, all showed similar growth rates. They also showed similar degrees of browning and popcorning when assessed subjectively. In short, these preliminary test results did not give any particular reason to choose one isolate over another. We chose KO as our principle test stain, since it had produced shiitake mushrooms in some preliminary tests.

Five different maitake strains were also assessed for growth on MGM agar. All looked similar to each other, forming white circular colonies with abundant aerial mycelium. All had radial growth rates of about 0.4 cm per day, except for DAOM 21005 which grew at 0.7 cm per day. When inoculated into sun bags containing the standard sawdust medium made with either oak or maple sawdust, all showed rapid growth, thoroughly permeating the medium within a few weeks. The substrate colonized by isolates XXX, YYY and DAOM 10235 became white with mycelial growth, and yellow liquid accumulated in the bottom of the bag. With DAOM 195185 or 21005 growth was more sparse and the wood particles remained visible. These isolates did not form yellow liquid. There was no reason to rule out any of the isolates, so we tested them all in subsequent mushroom production trials (see below).

2. Supplements. Combined nitrogen limits the rate of growth of wood decay fungi on sawdust (Boyle, 1998) so to increase growth, a suitable N source should be added. We compared various supplements using maple sawdust and shiitake strain KO in the mason jar test system. For the positive control, we used the basic medium with 20% red millet (by wt) as the principle N source. The negative control received no millet. The other supplements were added in place of the millet to give the same amount of N. After 7 weeks, mycelial growth, and browning and popcorning of the medium surface were assessed. The jars were then opened, and the medium pH was measured.

The results (Table 1) showed all supplements increased subjectively-measured growth over that measured with the control.

Growth with millet, fish meal, and feather meal were all high. The values for respiration were variable, although rates were highest with the millet. Browning was highest with feather meal, but millet and waste fish meal also giving a lot of browning. Popcorning was most pronounced with millet, followed by waste fish meal. Only soymeal did not support much browning or popcorning. None of the supplements dramatically affected the pH, it always being between 3.5 and 4.6, within the range that is good for shiitake growth (Boyle, 1992).

These results suggested that any of the supplements, with the possible exception of soymeal, might be used as a N source in place of millet. Some of them are much less expensive than millet.

Table 1. Comparison of effects of various supplements on mycelial growth, respiration and morphology of *L. edodes**, and on medium pH.

Supplement	Mycelial Growth	Respiration	Browning	Popcorning	pH
None (Bran only)	6	1.0 (0.5)	2	6	3.6
Millet	10	1.9 (0.9)	8	10	4.1
Soy meal	8	1.3 (0.5)	2	2	4.6
Waste Fish Meal	10	1.2 (0.5)	8	8	3.8
Herring Meal	8	1.1 (0.5)	2	6	3.5
Feather meal	10	1.2 (0.2)	10	6	3.8

*All parameters except respiration rated subjectively, 0-10, as described in materials and methods. Respiration is as mmol/hr/jar. Values are mean with the sd in parenthesis, n=3.

Apart from cost, supplements can affect resistance to contamination (Tokimoto and Komatsu, 1979). There is some indication that starch promotes the growth of *Trichoderma* sp. (Boyle 1999) this being the main contaminant of shiitake. Millet, bran and soymeal all contain starch, while fish meal and feather meal do not. This might make the latter two better supplements for shiitake than millet. We tested feathermeal as an alternative to millet in the larger scale mushroom production trials below.

3. Moisture Content Small scale tests were done to identify the optimal amount of water for shiitake growth. Tests were made with the standard medium. Mycelial growth was subjectively assessed (0-10) after 10 days. The results (Table 2) showed that growth was evident if the moisture content was higher than about 20%.

Table 2. The effect of moisture content and water potential on growth of shiitake.*

Moisture (%)	Water Potential (-MPa)	Growth (subjective, 0-10)
1	142	0
20	49	0
33	4	2
50	0.6	8
66	0.4	8

*Values are all for single determinations.

As the moisture content increased over 33%, the water potential rapidly approached 0 (water completely available) and this coincided with maximal growth. These results suggest that all things being equal, a moisture content of 33% or higher should be adequate for shiitake. Badham (1991) presented complimentary findings.

It is common practice to use a moisture content near 60% for shiitake production (Stamets 1993). However, we observed that blocks with a moisture level this high accumulated a lot of free water in the bag. We thought that this would impede oxygen diffusion through the medium, and encourage microbial contamination, so in our initial production experiments we aimed at a moisture content of about 45%. As shown below, we were misguided.

Mushroom Production. 1. Shiitake. We have made many tests of mushroom production using variations of the standard medium. In one experiment, we compared mushroom yields using twice the standard millet (treatment A), the normal amount of millet (B), 1/3 the normal amount of millet (C), the normal amount of millet replaced with feathermeal (D), the normal amount of millet, but without bran (E) or without millet but with the normal amount of bran (F). In all cases, the moisture content of the medium was about 45%. The bags were removed and the blocks were moved to the production room 12 weeks after inoculation. Subsequent flushes were induced by soaking the blocks in dilute javex/citrate for 3 hours. The results (Table 3) showed that mushrooms were formed in all treatments, with most production being on the first flush.

Table 3. Effects of medium composition on shiitake yield*

Treatment	First Flush	Second Flush	Third Flush	Maximum	Total
A 2X Millet	203(86)	61(54)	134(189)	761	398(256)
B 1X Millet	288(55)	110(82)	0(0)	544	398(79)
C 1/3 Millet	359(58)	72(51)	76(55)	561	507(72)
D Feathermeal	359(43)	16(23)	48(67)	444	424(18)
E No Bran	273(75)	155(82)	167(124)	762	596(223)
F No Millet	251(115)	155(149)	115(160)	810	515(268)

* Values are grams, and are means with the standard deviation in parenthesis. N= 4

Certain conclusions can be drawn from the data. Average yields in all treatments, including those with no bran or no millet were reasonably good. In some cases, individual blocks gave more than 800 g of mushrooms. These yields compare favorably with some that are reported in the literature (Donoghue and Denison, 1993) confirming that shiitake can be grown on maple sawdust. Interestingly, yields with the feathermeal were similar to those with millet, confirming that this could be used as an inexpensive replacement for millet. Also of interest is the lack of correlation between yield and amount of millet used. In this respect the results deviate from those Royce (1993).

Unfortunately, the standard deviation for much of the data was high making it impossible to identify statistically significant differences between treatments. This was in part due to the small number of replicates. (Most replicates had been sent to Hope Mushrooms, who would not provide yield data). It did seem likely that some factor other than N availability was limiting mushroom production in our blocks.

Before these blocks had been moved to the growing room, some representative ones were broken open, and it was noted that mycelial growth inside of them was sparse. In contrast, the outer part of the block was covered with a thick rind of mycelial growth. It seemed that the inside of the block was too dry, and that this might have been limiting mycelial growth in the preceding experiment.

We therefore did another experiment using various amounts of water in the medium. In this test, we used twice the normal amount of bran for reasons which are explained below. The results (Table 4) made it clear that yields were better with more water in the medium. When the standard deviation of the results was considered as a percentage of the mean (see number in *italics*), it became evident that a large part of the variability disappeared as the substrate moisture level increased.

These results contradicted those from our small-scale testing (table 2), where mycelial growth was only inhibited when the moisture was lower than about 33%. Our first thought was that evaporation through the breather patch on the bag was responsible for significant water loss during incubation. However, weighing the blocks showed that only about 20-40 mL of water was lost via this route, even when the incubation room was at low humidity. (About 40 - 80 g total weight was lost, but approximately half of this would have been carbon dioxide. This only represents a drop of a few percent in the medium's moisture content).

Moisture measurements showed that the substrate inside of the blocks became very dry (ca 30%, i.e. growth limiting) but the outside of the blocks actually became saturated during incubation. We concluded that the metabolic heat of the fungus was causing water to diffuse from the inside (warmer) part of the block to cooler outer layers, until it condensed onto the plastic. In many trials we added twice the original amount of bran, the idea being that this highly absorbent material would hold more water in the center of the block. We also increased the amount of water we added.

In another series of experiments, after opening the bags, we treated the blocks in a variety of ways. In treatment 1, the blocks were placed directly into the production room. In treatment 2, they were rinsed for 1 minute in tap water. In treatment 3, the blocks were rinsed in dilute bleach/citrate solution. (This had been the treatment we normally used.) In treatment 4 they were soaked for 5 hours in tap water.

The results (Table 5) showed that soaking for 5 hours improved the yield considerably over what was obtained by rinsing with either water, or bleach/citrate, or no treatment. There was no apparent advantage to using the bleach/citrate (for example no decrease in contamination of the blocks) and since it might present a health hazard (possible chloro-organic production), we abandoned this treatment.

This experiment was repeated, except that a wider range of soak times were tested. The results (Table 6) confirmed that yield was increased by soaking, the four hour soak giving the best yield.

Table 4. The effect of substrate moisture content on shiitake yield*.

Substrate moisture (%)	35%	40%	49%	53%	56%
Yield (g)	44g (72) *163*	103 (192) *186*	153 (202) *132*	178 (119) *67*	330 (58) *18*

Substate moisture measured when blocks made. Yields are g for first flush only. Values are means with the sd in parenthesis. N=3. The number in *italics* is the sd as a percent of the mean.

Table 5. The effect of rinsing or soaking blocks on mushroom yield*

Soak Treatment	None	Rinsed in tap water	rinsed in bleach/citrate	soaked 5 hours in tap water
Yield (g)	199 (100)	237 (97)	239(94)	418(142)

*Results are means with the sd in parenthesis for n=6. Yields are for first flush only.

Table 6. The effect of soak time on mushroom yield*

Soak Treatment	Rinsed 1 min.	Soaked 1 hour	Soaked 4 hours	Soaked 16 hours
Yield (g)	175 g	370 g	420 g	400 g

*Results are grams of mushroom per block and are means for 10. SD was not determined. Yields are for first flush only.

In another similar experiment, we soaked blocks for either 3 hours or 24 hours. We injected water into another set of blocks. The results (Table 7) showed that the 3-hour soak gave the best results.

It seems probable that the 24-hour soak made the inside of the block anaerobic (water-logged) and killed some of the mycelium.

The results with the injected blocks were of interest. Although the yield was not excellent, the technique showed some potential. Unfortunately, much of the water that was injected into the block dripped out soon after injection. It seems likely that results would have been better if the water had been injected more slowly, so the block would have had time to absorb it. After refinement, the injection technique might be preferred over soaking, since microbial cross contamination of blocks, such as occurs in an industrial soak tank, could be avoided.

Table 7. The effect of soak time and injection on yield*

Treatment	3 hour soak	24 hour soak	injected
Mushroom Yield (g)	434g	242g	294g

***Results are grams of mushroom per block and are means for 10. SD was not determined. Data for first flush only.**

As mentioned above, we added a lot of bran to improve the water-holding capacity of the medium. However, in subsequent tests we found that the high bran blocks were prone to contamination, often decomposing before giving a second or third flush of mushrooms. This was confirmed in 3 separate trials. The low bran blocks were much more resistant to contamination, and even under less-than-clean conditions they would continue to give mushrooms for many flushes. An example of results from is given in table 8.

The high bran blocks gave a better yield in the first flush, but in this experiment, all of them became badly contaminated before the second flush and were discarded, so the yield was 0. Yields from the low bran blocks were considerably better after three crops were collected. A fourth crop might also have been obtained, but we did not attempt this.

In another run of this experiment, we tested a medium in which much of the bran had been replaced with vermiculite. The results (Table 9) confirmed that the high bran blocks gave a very poor first flush and did not survive to the second flush. The low bran blocks did much better.

The blocks in which the bran was replaced with vermiculite did even better, with a final average yield after the fifth flush of 935 g (2.1 pounds). Some individual blocks gave more than 1400 g (3.2 pounds) of mushrooms. These results confirmed that excellent yields of shiitake can be obtained on hardwood substrates available in New Brunswick. The reported values compare favorably to those reported by others (Askey *et al.* 1999).

We thought that the low bran medium might have limiting amounts some nutrient needed for mushroom production. However, nutrient analysis of the medium, before inoculation, and after the first flush of mushrooms gave no indication that this was the case.

Table 8. Comparison of yield with high and low bran medium*

Composition	First Flush	Second Flush	Third Flush	Total
Low Bran	407g	225	113	745
High Bran	556	0	0	556

*Results are grams of mushroom per block and are means for 10. The SD was not determined.

Table 9. Shiitake yield from low bran, high bran and low bran + vermiculite blocks.

	Low Bran	High Bran	Low Bran + Vermiculite
First Flush	405(231)	187(194)	508(112)
Second Flush	20(28)	-	10(20)
Third Flush	130(103)	-	50(58)
Fourth Flush	168(83)	-	349(157)
Fifth Flush	23(46)	-	18(35)
Total	746(491)	187(194)	935(382)

The results are the mean with the sd in parenthesis. N=6.

Table 10. Composition of medium before and after mushroom production*.

	Non-inoculated Medium	Medium after Production
Nitrogen (%)	0.81	0.88
Carbon (%)	44	36
Phosphorus (%)	0.15	0.21
Magnesium (%)	1.09	2.42
Potassium (%)	0.48	0.79
Copper (ppm)	5.4	11.2
Iron (ppm)	3626	7822
Manganese (ppm)	92	189
Sodium (%)	0.01	0.02
Zinc (ppm)	20	124
Boron (ppm)	13	26

*values are for single determinations, and are on a dry wt basis.

Surprisingly, all of the components, except C actually increased. It seems probable that the shiitake mycelium degraded more of the C than the other nutrients, so that the effective concentrations of them increased with growth. A more intensive investigation might substantiate this.

We have done a number of tests with different shiitake strains using the low bran, vermiculite medium. In one test, we compared strain KO to strain 4000, WSB, 602 and Wil. Only KO and 4000 produced any mushrooms, and yields were much higher with KO (data not presented). It may be that this strain is better than the others, or perhaps we selected conditions that were particularly well suited for it.

We now produce our blocks using a low bran + vermiculite medium with isolate KO. Often, due to our limited growing area, we only take the first flush off of the blocks. In some cases average first flush yields are 600 g.

We sometimes have problems with high variability. At least a part of this is due to the center of the blocks becoming too dry. We continue to look for methods to retain more water within the blocks. We think this will lead to even better yields. Part of the variability also results from poor environmental control. It is probable that yields would be better in a properly designed (commercial) growing facility.

2. Maitake and Other Species. In a first test, we made 6 blocks of each maitake strain, using the high bran shiitake medium with maple sawdust. The blocks did not brown and popcorn like shiitake did, the outside surface remaining light-colored. We moved the blocks to the production room 9 weeks after they were inoculated. The bags were slit to drain accumulated liquid, but the bags were not removed. After about 1 wk, some grey-brown convoluted hymenial structures characteristic of *G. frondosa* formed on 2 of the 6 XXX blocks, 1 of the 6 YYY blocks and on 1 of the 6 strain #10235 blocks. Unfortunately, these structures did not develop into fully formed mushrooms, but remained appressed to the block. The other blocks all became contaminated and had to be discarded.

We repeated the trial a second time using the low bran, vermiculite medium that gave good results with shiitake. We only used strain XXX, and made 12 blocks with oak sawdust and 12 with maple. We did not notice any difference in mycelial growth on the two media. The blocks were moved into the production room after 10 weeks. Only three blocks made any mushrooms. Interestingly, all of these were with the maple sawdust medium. (The XXX strain had been isolated from a mushroom growing on oak, so better performance on maple sawdust was surprising). In all cases the mushrooms remained small (ca 100 g), although they developed form similar to that of the mushroom from which XXX had been isolated. It seems probable that larger mushrooms could be grown on this medium under more appropriate (probably cooler) production conditions.

We have also produced mushrooms with reishi (*Ganoderma lucidum*) and lion's mane (*Hericium corraloides*) isolates, using the medium we used for shiitake. Both of these started to produce mushrooms in the incubation room before the sun bag was opened. The reishi continued to grow in this bag, forming antler-like morphology in response to the high CO_2 environment. For the lion's mane, we moved the bag into the production room, and cut a hole around the developing mushroom. It continued to grow to give a beautiful 500 g mushroom.

We have also occasionally produced oyster mushrooms. We produced these on pasteurized alfalfa straw contained in a bucket. The *P. ostreatus* gave grey-brown mushrooms, while the *P. citrinopileatus* gave bright yellow mushrooms. We made no attempt to improve yield, but there is little question that either of these could be produced commercially - Oyster mushrooms are notoriously easy to grow.

The author has slides showing each of these mushrooms. (They are not presented here since color printing is not available, but they are available for viewing on request.)

Conclusions

The results show that high shiitake yields can be obtained using nutrient-amended surplus hardwood sawdust that is available in New Brunswick. It seems probable that increasing amount of shiitake will be produced in N.B. It should be a good crop for export.

In the course of the work it became clear that many of the factors affecting mushroom yield are interdependent. For example, medium composition affects growth rate that, in turn, affects heat production that affects water diffusion in the blocks, etc. This interdependence of factors requires that an iterative approach be taken to block development. We continue with this process and our blocks continue to improve.

The mushroom yields reported here were obtained in a production room with a very simple (inexpensive) system for controlling temperature, light and humidity. Better, and less variable yields would be expected in a commercial setting. Some preliminary tests made with a commercial grower have been encouraging. Maritime MicroBiologicals is looking for partners who might be interested in pursuing commercial production.

Results with other specialty mushrooms have also been encouraging. Maitake is an excellent edible mushroom with a good shelf life. Although our yields were small, it seems likely that these could be much better in a proper production facility where a lower temperature could be attained.

Oyster mushrooms are easy to grow, and they come in a variety of shapes and sizes. The *P. citrinopileatus* mushrooms were an attractive bright yellow, and this might give them a place in a specialty market niche. The lion's mane is also easy to grow, and has a strong visual appeal and good flavour. It is fragile though, so it would be difficult to market.

The reishi mushrooms also have high visual appeal. They are too tough to eat, but they might be marketed as ornamental 'plants'. They also have high nutriceutical value, and are reported to have many positive effects on health (see various articles in the book edited by Royse 1996). All of these species are being grown in other parts of the world, and interest in them is increasing in North America.

If any readers are interested in growing (or discussing) specialty mushrooms, please contact the author.

Acknowledgments

We thank the New Brunswick Department of Agriculture and Rural Development for support for this project through the Strategic Partnership Development Fund. Excellent technical assistance was provided by Mona Levesque, Michael Ramey and Kevin Orpen.

Literature Cited

Askey, M., R. Noble and Adreja Dobrovin-Pennington. 1999. Cultivation of Shiitake on different sawdust substrates. Mushroom News. 47:4-7.

Badham, E. R. 1991. Growth and competition between *Lentinus edodes* and *Trichoderma harzianum* on sawdust substrates. *Mycologia*. 83:455-463.

Boyle, D. 1999. Why mushrooms are not wiped out by green mould. *Mushroom World*. 10(4): 5-10.

Boyle, D. 1992. Ph.D. thesis. (Available on request).

Boyle, D. 1998. Nutritional factors limiting the growth of *Lentinus edodes* and other white rot fungi on wood. *Soil Biol. Biochem.* 30(6):817-823.

Boyle, C.D. and B.K. Kropp. Development and comparison of methods for measuring growth of filamenous fungi on wood. Can. J. Microbiol. 38: 1053-1060.

Donoghue, J.D. and W. C. Denison. Commercial production of shiitake (*Lentiula edodes*) using whole-log chip of *Quercus*, *Lithocarpus* and *Acer*. In Royce, D. J. (Ed) Mushroom Biology and Mushroom Products. Proceedings of the 2nd International Conference. June 9-12, 1999. Penn. State Univ. Univer

Eliot, T.J. 1985. Spawn-making and spawns. Chapter 8 *in* Flegg P.B., D.M. Spencer and D.A. Wood (eds). The Biology and Technology of the Cultivated Mushroom. John Wiley and Sons. Ltd. New York.

Kramer, P.J. 1969. Plant and Soil Water Relationships: A Modern Synthesis. McGraw-Hill, San Francisco.

Rinker, D. and W. Chalmers. 1998. Specialty mushroom industry in Canada. *Mushroom World*. 9(4): 7-8.

Royce, D. L. 1993. Yield stimulation of shiitake by millet supplementation of wood chip substrate. In Royce, D.J. (Ed) Mushroom Biology and Mushroom Products. Proceedings of the 2nd International Conference. June 9-12, 1999. Penn. State Univ.

Stamets, P. 1993. Growing Gourmet and Medicinal Mushrooms. Ten Speed Press. CA.USA. 555 pps.

Tokimoto, K and Komatsu, M. 1979. Effect of carbon and nitrogen sources in media on the hyphal interferecnce between *Lentinus edodes* and some species of *Trichoderma*. *Ann. Phytopath. Soc. Japan*. 45:261-264.

CEREALS AND PROTEIN CROPS / CÉRÉALES ET CULTURES PROTÉAGINEUSES

SOIL TILLAGE MANAGEMENT OF DYKELAND SOILS FOR BETTER CROP DIVERSIFICATION AND WILDLIFE USE - EFFECT ON AGRONOMIC PERFORMANCE

GESTION DU TRAVAIL DES SOLS MARÉCAGEUX POUR AMÉLIORER LEUR DIVERSIFICATION VÉGÉTALE ET LEUR UTILISATION PAR LA FAUNE - EFFET SUR LA PERFORMANCE AGRONOMIQUE

Vernon Rodd[1], Jason Wells[2], Roger Thériault[3], Herb Rees[4], Lien Chow[4], Ken Webb[5], Ken McRae[6], Keith MacAloney[7], John Wile[8], Reg Melanson[7], Laurie Collette[3], Rob Gordon[9], Sherry Fillmore[6] and/et Brad Walker[6]

Partners / Partenaires: Phillip Pederson (Philarik Acres Ltd.), Robert Acton (R.A. Farms), Terry Lister (CORCAN), Chignecto Soil and Crop Improvement Association / Association pour l'amélioration du sol et des cultures de Chignecto, Cumberland County Soil and Crop Improvement Association / Association pour l'amélioration du sol et des cultures du comté de Cumberland, Ducks Unlimited Canada and Eastern Habitat Joint Venture / Canards Illimités Canada, Eastern Habitat Joint Venture.

Abstract: In 1997, a multi-year trial was established at three sites, Amherst Point, NS; Sackville, NB and Dorchester to evaluate conventional, zero and minimum tillage systems on the dykelands. This was is an extensive project which examines the effect the various tillage treatments on agronomic performance, soil properties and wildlife use. The first year of the trial, 1997, was used to collect background data on soil chemical and physical properties. Thus, the tillage treatments have only been applied for the last two years. Only agronomic performance will be reported at this time; the effect of the tillage practices on the other two objectives will take a number of years to discern. The tillage treatments were applied prior to seeding the cereal crops. During the growing season, the days to 100% crop emergence, plant populations, seeding depth, and yield, both at boot-stage and maturity were monitored. Of the soil parameters monitored, only soil moisture status at seeding and residue cover are reported. The tillage treatments did not significantly affect days to 100% emergence, boot-stage yield and grain yield. It was noted that seeding depth, although not affected by the tillage treatments, needs to be closely monitored. Soil moisture content at seeding was significantly higher with the minimum and zero-tillage treatment in the spring of 1999. In both years, residue cover was greatest with zero-tillage and least with conventional-tillage. Data to date suggests that zero and minimum tillage systems are comparable in agronomic performance to conventional tillage systems on the dykeland soils.

---

[1] Agriculture and Agri-Food Canada, Nappan, NS / Agriculture et Agroalimentaire Canada, Nappan, N.-É.

[2] Cumberland County Soil and Crop Improvement Association, Nappan, NS / Association pour l'amélioration du sol et des cultures du comté de Cumberland, Nappan, N.-É.

[3] Regional Office, NBDARD, Moncton, NB / Bureau régional, MAARNB, Moncton, NB

[4] Agriculture and Agri-Food Canada, Fredericton, NB / Agriculture et Agroalimentaire Canada, Fredericton, NB

[5] Agriculture and Agri-Food Canada, Truro, NS / Agriculture et Agroalimentaire Canada, Truro, N.-É.

[6] Agriculture and Agri-Food Canada, Kentville, NS / Agriculture et Agroalimentaire Canada, Kentville, N.-É.

[7] Canadian Wildlife Service, Environment Canada, Sackville, NB / Service canadien de la faune, Environnement Canada, Sackville, NB

[8] Ducks Unlimited Canada, Amherst, NS / Canards Illimités Canada, Amherst, N.-É.

[9] Nova Scotia Agricultural College / Collège d'agriculture de la Nouvelle-Écosse

Résumé : Un essai pluriannuel lancé en 1997 à Amherst (N.-É.), à Sackville (N.-B.) et à Dorchester avait pour but d'évaluer divers systèmes de travaux du sol (labour conventionnel, semis direct et travail du sol minimal) dans les terrains marécageux. On voulait déterminer l'incidence de divers travaux du sol sur la performance agronomique, les propriétés des sols et leur utilisation par la faune. Durant la première année de l'essai (1997), on a recueilli des données de base sur les propriétés chimiques et physiques du sol. Ainsi, les travaux du sol ont seulement été appliqués ces deux dernières années. La performance agronomique est le seul élément traité ici, car il faudra attendre quelques années pour déterminer les effets des travaux du sol sur les deux autres éléments. Les travaux ont été faits avant le semis des cultures céréalières. Durant la saison de croissance, on a recueilli des données sur la période de levée complète, sur la population végétale, sur la profondeur de semis et sur le rendement, à la fois au stade du gonflement et à la maturité. Les seuls paramètres pédologiques déclarés étaient l'humidité du sol au semis et la couche de résidu. Les travaux du sol n'ont pas beaucoup modifié la période de levée complète, le rendement au stade du gonflement et le rendement céréalier. On a indiqué que la profondeur de semis n'a pas été affectée par le travail du sol, mais il faut surveiller attentivement ce facteur. Au printemps 1999, l'humidité du sol au semis était beaucoup plus élevée dans les cas de travail minimal et de semis direct. Durant les deux années, la couche de résidu était plus considérable aux endroits où il n'y avait pas eu de travail du sol, et plus mince aux endroits soumis à un labour conventionnel. Les données recueillies à ce jour indiquent que les systèmes de culture sans travail du sol et avec un travail minimal donnent une performance agronomique comparable à celle d'un travail du sol conventionnel dans les sols marécageux.

Introduction

Generally, arable agriculture occurs in sub-humid and semiarid regions of the world where potential evaporation is high and precipitation is moderate (Carter 1994). Thus, it is in regions, such as central and western Canada and the United States, that zero tillage and other conservation tillage systems have achieved greatest acceptance. More humid areas, such as the Maritimes, are characterized by relatively low evaporation and high precipitation. This coupled with excessive plant residues, often leads to conditions of excess soil moisture which results in soil compaction and cooler soil temperatures at seeding time; constraints in the adoption of reduced tillage practices (Carter 1994).

Compared to conventional tillage, the yields under zero tillage have been variable. On coarse textured well-drained soils, yields between conventional and zero tillage systems have been comparable (O'Sullivan and Ball 1982; Carter 1988; Vyn et al. 1994). However, on finer textured soils with poor internal drainage, yields under zero tillage have generally been less than under conventional tillage (Videnovic et al. 1986; Vyn et al. 1994; Stecker et al. 1995).

There are approximately 30,000 hectares of fertile, fine textured silty clay loam dykeland soils, in Nova Scotia and New Brunswick. The agricultural use of these soils is limited by poor internal drainage. Water is removed by surface drainage systems which includes land-forming. Plowing and other cultivation practices which disrupt the soil surface can result in the land remaining wet for extended periods of time, delaying seeding, and reducing yield. Also, since the salt content of these soils increases with depth (Rodd et al. 1993), primary tillage implements which invert the soil can bring up excess salts in concentrations deleterious to crop production. These problems have resulted in many farmers utilizing their dykelands primarily for perennial forage production versus production of annual crops such as cereals.

Many dykeland farmers are interested in tillage systems which allow for crop establishment while at the same time preserving the land-formed topography. There may be a potential for growing cereals on these soils through the use of zero and minimum tillage systems. The purpose of this project is to compare zero, minimum and conventional tillage systems for establishment of cereal crops on the dykelands.

Materials and Methods

Experimental Sites. Experimental sites were located in the summer of 1996 at the Westmorland Institution of CORCAN, Dorchester, NB, R.A. Farms, Sackville, NB and Philarik Acres, Amherst Point, NS. The sites chosen represented average improved (land-formed) dykeland soils with reasonable lime status (pH >5.8). Although these sites had been land-formed previously, there were sufficient small depressions that the project team decided that further land smoothing was warranted. Small depressions prevent the removal of surface water, imperative for early crop establishment on dykeland soils. It should be noted that prior to farmers implementing zero and minimum tillage systems on the dykelands, the surface drainage system must be in good repair. Land smoothing occurred at the Dorchester and Amherst Point sites in the spring of 1997 and the Sackville site in the fall of 1997. New culverts were installed in Dorchester and the ditches in Dorchester and Sackville cleaned.

At each site, 6 dales were subdivided into three treatments and three replications. This was accomplished by placing the minimum and zero tillage treatments on opposite sides of the same dale. Subsampling areas were delineated on each treatment. The Dorchester site had four subsampling areas in each treatment while the Sackville and Amherst Point sites had three. The subsampling areas were further subdivided into run and crown locations.

Cropping Practices. The tillage treatments were defined as follows: Conventional tillage consisted of one or two passes with a disc harrow, a pass with a spring tooth or S-tine harrow followed by seeding with a Tye no-till drill. Minimum tillage consisted of a light scratch with the spring tooth, rotary hoe or S-tine harrow (whatever the farmer has at his disposal), followed by seeding with a Tye no-till drill. Zero tillage was direct seeding with a Tye no-till drill. Roundup was applied prior to application of the treatments. Oats (Avena sativa cv AC Capital) and barley (Hordeum vulgare cv Chapais) were the crops grown in 1998 and 1999, respectively. The oats were seeded on 27 May at the Amherst Point and Sackville sites and 28 May and 31 May at the Dorchester site. The barley was seeded on 19 May at the Amherst Point and Sackville sites and 24 May at the Dorchester site.

Plant Parameters Measured. The row and crown locations at each subsampling area was monitored for the date of 100% plant emergence. After full emergence was reached, plant populations were determined by counting the number of plants along three adjacent 1m sections. Seeding depth, determined on the same date as the plant populations, was measured by averaging the depth of seeds from three adjacent rows on the run and crown area locations of each subsampling area.

Above ground dry matter production was determined by harvesting at boot stage two 1600.2cm^2 (3 rows @ 17.78cm spacing in width by 30cm in length) samples from the run and crown locations of each subsampling area. The samples were dried at 70°C, and weighed.

Grain yield was determined by harvesting sections on the run and crown locations near each subsampling area with a Hege plot combine. The grain samples were air dried, cleaned, and weighed.

Soil Parameters Measured. Soil volumetric moisture content in the top 15 cm of soil was monitored at seeding using a Trase Time Domain Reflectometer.

Residue cover was monitored using the line transit technique.

Results

Plant Parameters. Days to 100% crop emergence were significantly affected by site and position on the dale but were unaffected by the tillage treatments in both years (Table 1). The order of the sites to reach 100% emergence was Sackville, Amherst Point and Dorchester in 1998 and Amherst Point, Dorchester and Sackville in 1999. The 1998 results were due impart to variable seeding depth (Table 1). In 1999 we are uncertain why there was a significant site effect on the days to 100% emergence. The cereals achieved 100 % emergence earlier on the crowns than in runs (Table 1). This appeared to be due to the differences in the soil environment between the two locations.

In 1998, there was a significant effect of site on seeding depth (Table 1). This was due to deeper seed placement at the Dorchester site. In 1999, there was no effect of site on seeding depth (Table 1). Cylinder-lock clips were used at all sites in 1999 and appeared to have prevented the seeds from being placed too deep. This is an important concern, as seeds placed too deep can delay crop emergence, lower plant populations and reduce yield. In both years, there was no effect of any of treatments nor location on the dale on seeding depth.

Table 1. Days to 100% crop emergence, seeding depth and plant populations

	Days to 100% emergence (days)		Seeding depth (cm)		Plant populations (plants ha^{-1})	
Year	1998 (Oats)	1999 (Barley)	1998 (Oats)	1999 (Barley)	1998 (Oats)	1999 (Barley)
Site						
Amherst Point	15.7	21.7	2.42	2.09	4756000	2475000
Sackville	15.0	33.0	2.58	2.3	3416000	1556000
Dorchester	16.7	28.0	4.41	2.16	3548000	1542000
SEM^z	0.159	0.057	0.149	0.062	68485	54698
F Prob.^{y}	<0.001	<0.001	<0.001	0.114	<0.001	<0.001
Tillage						
Conventional	16.2	27.5	3.38	2.16	3570000	1872000
Minimum	15.8	27.7	3.29	2.18	3916000	1792000
Zero	15.7	27.7	3.13	2.21	4125000	1814000
SEM^z	0.172	0.077	0.085	0.050	103170	80130
F Prob.^{y}	0.15	0.097	0.146	0.738	0.005	0.771
Position						
Run	16.0	27.7	3.31	2.17	3768000	1729000
Crown	15.8	27.6	3.22	2.2	3974000	1924000
SEM^z	0.064	0.037	0.051	0.036	67050	46365
F Prob.^{y}	0.005	0.087	0.23	0.507	0.031	0.003

^{z}SEM denotes the standard error of the mean and is used in all tables

^{y}F Prob. denotes the f probability and is used in all tables, with a value <0.05 meaning statistic significance

Plant populations differed significantly among sites and position on the dale in both years (Table 3). In both years the Amherst Point site had the highest plant population. The lower plant population at the Dorchester site in 1998 was thought to be due to deep seed placement. We are uncertain as to why there were significant plant population differences among the sites in 1999. The runs had lower plant populations than the runs in both years (Table 3) due in part to differences in the soil environment. There was a significant effect of the tillage treatments in 1998, but not in 1999. In 1998, the zero and minimum tillage treatments had higher plant populations than the conventional.

There was a significant effect of site on boot-stage yield and grain yield (Table 2). Amherst Point had the highest yields followed inturn by Sackville and Dorchester. The lower yield at the Dorchester site was probably due inpart to the deeper seeding depth in 1998 and weather conditions in 1999. Less yield was obtained from the run than the crown positions. The lower yields in the runs are probably due to the soil environment. The boot stage dry matter yield and the grain yield were not affected by the tillage treatments (Table 2).

Table 2. Boot stage yield and grain yield

	Boot Stage Yield (t ha^{-1})		Grain Yield (t ha^{-1})	
Year	1998 (Oats)	1999 (Barley)	1998 (Oats)	1999 (Barley)
Site				
Amherst Point	3.38	2.2	4.79	3.6
Sackville	2.95	1.85	4.21	3.23
Dorchester	1.83	1.04	3.02	2.36
SEM[z]	0.185	0.087	0.127	0.162
F Prob.[y]	0.002	<0.001	<0.001	0.003
Tillage				
Conventional	2.52	1.60	3.99	2.99
Minimum	2.60	1.67	3.89	2.95
Zero	2.77	1.62	3.85	3.08
SEM[z]	0.126	0.084	0.13	0.059
F Prob.[y]	0.371	0.827	0.74	0.272
Position				
Run	2.33	1.38	3.53	2.4
Crown	2.93	1.88	4.28	3.61
SEM[z]	0.080	0.053	0.069	0.068
F Prob.[y]	<0.001	<0.001	<0.001	<0.001

Soil Physical Parameters. The soil moisture content at seeding (0-15cm) was affected by site in both years, and by tillage treatments in 1999 (Table 3). The Dorchester site was wetter than the Sackville, and Amherst Point sites. In 1999, the soil in the top 15 cm was wetter under zero and minimum tillage than conventional tillage. Position on the dale did not seem to influence the moisture content at seeding (Table 3).

There was a significant effect of site and tillage on the amount of surface residue in both years (Table 3). Surface residue was lowest at the Sackville site and highest at the Amherst Point site. The zero-tillage treatment had the highest surface residue followed inturn by the minimum-tillage and the conventional-tillage treatments. There was no difference in the amount of residue cover in the runs and on the crowns (Table 3).

Table 3. Soil moisture at seeding and residue cover

	Soil moisture at seeding (%)		Residue cover (%)	
Year	1998 (Oats)	1999 (Barley)	1998 (Oats)	1999 (Barley)
Site				
Amherst Point	35.02	22.53	46.4	42.4
Sackville	35.53	25.25	2.5	18.4
Dorchester	38.67	31.24	40	33.6
SEM[z]	0.727	1.184	2.070	1.376
F Prob.[y]	0.016	0.004	<0.001	<0.001
Tillage				
Conventional	36.69	23.60	20.8	5.6
Minimum	36.34	29.36	31.3	39.6
Zero	36.87	27.53	40.2	49.8
SEM[z]	0.798	0.449	3.460	3.440
F Prob.[y]	0.892	<0.001	0.004	<0.001
Position				
Run	37.05	27.18	31.5	32.7
Crown	36.22	26.49	29.9	30.7
SEM[z]	0.445	0.450	0.777	0.835
F Prob.[y]	0.192	0.281	0.142	0.098

Conclusions

When applying zero tillage principles to dykelands, it is extremely important that surface drainage systems are in good repair. It is also necessary to watch seeding depth, as a deep seed placement results in poor emergence and poor yields regardless of the tillage treatment. Since there are only two years of agronomic data it is hard to draw firm conclusions about the long-term viability of zero and minimum tillage systems for cereal production on the dykelands, however, the results to date have been promising. Yields under these two systems have been comparable to yields under conventional tillage.

Acknowledgements

The authors would like to thank all cooperators, as well as acknowledge financial support from Eastern Habitat Joint Venture, Ducks Unlimited Canada, New Brunswick Department of Agriculture and Rural Development's Strategic Partnership Development Fund, and Agriculture and Agri-Food Canada's Matching Investment Initiative program.

References

Carter, M.R., 1988. Temporal variability of soil macroporosity in a fine sandy loam under mouldboard ploughing and direct drilling. Soil and Tillage. Research. **12**: 37-51.

Carter, M.R. 1994. A review of conservation tillage strategies for humid and temperate regions. Soil and Tillage Research. **31**: 89-301.

O'Sullivan, M.F., and B.C. Ball. 1982. Spring barley growth, grain quality, and soil physical conditions in a cultivations experiment on a sandy loam in Scotland. Soil and Tillage Research. **2**: 359-378.

Rodd, A.V., K.B. MacRae, J.B. Harnish, and H.W. Kolstee. 1993. Soil properties associated with formation of barren areas on formed dykelands cropped to forage. Canadian Journal of Soil Science. **73**: 527-538.

Stecker, J.A., Buchholz, D.D., Hanson, R.G., Wollenhaupt, N.C., and K.A. McVay. 1995. Tillage and rotation effects on corn yield response to fertilizer nitrogen on Aqualf soils. Agronomy Journal. **87**: 409-415.

Videnovic, Z., Vasic, C., and F. Kolcar. 1986. Effect of fertilizers and soil tillage on corn yield under dry farming and irrigated conditions. Soil and Tillage Research. **8**: 113-118.

Vyn, T.J., Janovicek, K., and M.R. Carter. 1994. Tillage requirements for annual crop production in Eastern Canada. Pages 47-71. *In* M.R, Carter ed. Conservation tillage in temperate agroecosystems. Lewis Publishers. Boca Raton.

HYBRID CANOLA SEED HARVEST MANAGEMENT STUDY-NEW BRUNSWICK, 1999

ÉTUDE SUR LA TECHNIQUE DE RÉCOLTE DES GRAINES DE CANOLA HYBRIDE – NOUVEAU BRUNSWICK 1999

D.F. Walker[1], D. MacLoon[2], A.O.M. Smith[1] and/et P.D. Sandeson[2]

Partner/Partnenaire: New Brunswick Soil and Crop Improvement Association/ Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick.

Abstract: In 1999 a hybrid canola seed harvest management study was undertaken to determine the potential use of a desiccant as a harvest aid compared to the traditional method of swathing in New Brunswick. An argentine variety of canola was subjected to desiccation and swathing methods then harvested at three different moisture levels (10%, 12.5%, 15%). Treatments were evaluated by measuring yield, vigor, percent germination and percent harvest moisture. The desiccated plots had a significant lower % vigor ranging from 82% to 84% than the swathed plots which ranged from 89% to 94% however it was still in the acceptable range of 20 units of the % germination. Similarly, the % germination ranging from 89% to 94% for the desiccated plots was significantly lower than the swathed plots which ranged from 94% to 96% but still in an acceptable range. Desiccated canola exhibited a significantly faster drying down time than the canola laying in a swath indicating harvest could commence earlier in the fall.

Résumé : Une étude sur la technique de récolte des graines de canola hybride a été réalisée en 1999 pour établir l'utilité éventuelle d'un dessiccant comme aide à la récolte, comparativement à la méthode traditionnelle de l'andainage au Nouveau-Brunswick. Une variété de canola argentine a été traitée avec un dessiccant et andainée, et la récolte a eu lieu à trois différents taux de teneur en eau des grains (10 %, 12,5 %, 15 %). Les paramètres analysés étaient le rendement, la vigueur, le taux de germination et la teneur en eau à la récolte. Les parcelles traitées avec le dessiccant présentaient une vigueur bien inférieure à celle des parcelles andainées, soit de 82 à 84 % et de 89 à 94 % respectivement, mais le taux de germination restait quand même dans la limite acceptable de 20 unités. De plus, le taux de germination de 89 à 94 % dans les parcelles traitées avec un dessiccant était beaucoup inférieur à celui de 94 à 96 % dans les parcelles andainées, mais il restait quand même en deça de la limite acceptable. Le canola traité au dessiccant avait un temps de séchage beaucoup plus court que le canola andainé, ce qui indique que la récolte pourrait débuter plus tôt à l'automne.

Introduction

New Brunswick has an excellent growing season for canola however the harvest season can be wet forcing farmers to leave canola in the swath for weeks before reaching the desired moisture level for combining. Heavy rains can beat swaths through the stubble to the ground resulting in a loss of yield, sprouting and low vigor. Canola seed with low vigor has been a concern for several years not only to New Brunswick producers but also to seed growers in western Canada. Research is in progress to determine the cause and to develop a more reliable method of testing. Canola that is standing dries faster after a rainfall due to the pods being up off the ground allowing for better air circulation, reducing sprouting and decreasing the effect on vigor. Western studies indicate that argentine varieties are more prone to shattering suggesting desiccation should only be used in badly lodged fields. Unlike western conditions wind is not usually a significant concern in New Brunswick. Seed loss during harvest time would most likely be due to handling. Desiccation can also be considered in fields that mature unevenly due to the rolling topography or because of uneven plant emergence (Thomas, 1995). Uneven maturity makes it difficult to determine the time of swathing and it is impractical for producers to swath sections of the field at different times. Chemical desiccation results in a more uniformly ripened crop (Thomas, 1999). The desiccant registered for canola in New Brunswick is Reglone (common name: Diquat). It is applied at a rate of 1.5 - 2.75 L/ha at a retail price of $25.80 /litre. The cost per acre would be $36.53 for the lowest application rate.

---

[1] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de l'élevage et de l'alimentation des animaux, MAARNB, Fredericton, NB E3B 5H1

[2] New Brunswick Soil and Crop Improvement Association, 16 Gilks Road, Maugerville, NB / Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick, 16, chemin Gilks, Maugerville, NB

Reglone is rapidly absorbed by the vegetation and there is no residue because of the adsorption of the chemical to soil particles. Reglone is widely used as topkill in potato crops therefore it is readily available to the producers.

Due to the increased interest in hybrid canola seed production a hybrid seed canola harvest management study was undertaken to determine the potential use of a desiccant as a harvest aid compared to the traditional method of swathing in New Brunswick.

Materials and Methods

Female and male canola lines were seeded in Woodstock on May 11 using a conventional seed drill. The seeding rate was 10 lbs/ acre consisting of 6 lbs of canola seed and 4 lbs of granular insecticide. The female (A line) and male (R line) seed were planted in separate strips with a width of 17 feet and 5 feet respectively. Trammlines at 18 inches were left between the male and female strips. Flea beetles were controlled by the granular insecticide counter seeded with the canola seed. Ammonium nitrate was applied at a rate of 90 Kg N/ ha. Treflan 480 was applied at the recommended rate of 2.0 L/ ha and incorporated prior to planting. The field was monitored for tarnished plant bugs (lygus) and when threshold levels were reached an application of Dylox 420 was made at the recommended rate of 0.85 L/ ac. The field was randomly divided into reps to be swathed and reps to be desiccated. Swathing occurred on Aug 17 and the desiccant was applied on Aug 19. Harvesting took place between Aug 25 and Aug 31 attempting to achieve three moisture levels (10%, 12.5%, 15%) with a Hege plot combine. A hand held digital moisture meter was used to determine the level of moisture of the seed. All plants in the swath were harvested whereas only a strip from the middle of the desiccated plot measuring 1.5m X 7m was directly cut.

Results and Discussion

Yields ranged from 1.13 - 1.55 t/ ha at 10% moisture. LSD tests (0.05) concluded little or no significant difference of yields between early harvest (15% moisture) vs. late harvest (10% moisture), and desiccated vs. swathed plots. All desiccated plants within a plot should have been harvested similar to all swathed plants. Canola plants on the outside of the female bay (near the male bay) are higher yielding than the plants in the middle of the bay. Because a strip of desiccated canola was combined from the middle of these plots the higher yielding plants were not harvested therefore producing biased results. Further testing in this area is required.

Percent germination ranged from 89.3% - 93.8% for the desiccated plots and 94.4% - 96.0% for the swathed plots (Table 1). An LSD test (0.05) shows there is a significant difference between % germination at the different harvest moistures. At the early harvest (15% moisture) there is no significant difference in % germination between desiccated and swathed plots, however, at the mid harvest (12.5% moisture) and late harvest (10% moisture) there is significant difference showing the desiccated plots to have a lower % germination than the swathed plots.

Significant differences are recognized in the actual % harvest moistures at the early (15% moisture) and mid (12.5% moisture) harvest times between the desiccated and swathed plots (Table 2).

The standing desiccated canola dries down at a faster rate than the canola lying in the swath (Table 3). At all harvest times the swathed plots had 1 to 2 additional days to dry down than the desiccated plots, however, the actual harvested moisture content of the desiccated plots are significantly lower than the swathed plots. This can be attributed to the pods being up off the ground allowing for better air circulation through the plants. In the swathed plots the plants are lying on stubble with the pods closer to ground. Air cannot circulate efficiently under the swath causing the pods to stay damp for a longer period of time.

Seed size ranged from 5.32 - 5.88 grams per thousand seeds for both desiccated and swathed plots. This is the size normally achieved for this hybrid in New Brunswick. Analyses shows that there is no significant differences in thousand seed weight between swathed and desiccated plots (Table 4).

Table 1. Comparison of mean % germination of desiccated vs. swathed canola at early, mid and late harvest (15%, 12.5%, 10% moisture)

	Mean % Germination		
Harvest Time	Early (15% H_2O)	Mid (12.5% H_2O)	Late (10% H_2O)
Desiccated	93.8 AB	89.3 C	92.1 B
Swathed	94.4 AB	96.0 A	94.9 A
LSD (0.05)	2.64		
CV (%)	7.46		

* Means followed by the same letter are not significantly different by LSD test (0.05)

Table 2. Comparison of mean actual % harvest moisture of desiccated vs. swathed canola at early, mid, and late harvest (15%, 12.5%, 10% moisture)

	Mean Actual % Harvest Moisture		
Harvest Time	Early (15% H_2O)	Mid (12.5% H_2O)	Late (10% H_2O)
Desiccated	11.50 B	8.50 D	6.63 E
Swathed	15.80 A	9.75 C	7.00 E
LSD (0.05)	1.17		
CV (%)	1.77		

* Means followed by the same letter are not significantly different by LSD test (0.05)

Table 3. Comparison of actual days to harvest of desiccated vs. swathed canola at early, mid, and late harvest (15%, 12.5%, 10% moisture)

	Harvest Time	Days to Harvest	Harvest Moisture (%)	Date Harvested
Desiccated	Early	8	11.50	Aug 26
	Mid	9	8.50	Aug 27
	Late	13	6.63	Aug 31
Swathed	Early	9	15.80	Aug 25
	Mid	11	9.75	Aug 27
	Late	15	7.00	Aug 31

Swathed: Aug 17
Desiccated: Aug 19

Table 4. Comparison of mean thousand seed weight (grams) of desiccated vs. swathed canola at early, mid and late harvest (15%, 12.5%, 10% moisture)

Harvest Time	Early (15% H_2O)	Mid (12.5% H_2O)	Late (10% H_2O)
Desiccated	5.56 A	5.44 A	5.80 A
Swathed	5.50 A	5.66 A	6.08 A
LSD (0.05)	0.66		
CV (%)	4.23		

* Means followed by the same letter are not significantly different by LSD test (0.05)

Vigor test results showed that desiccated plots had a lower % vigor at all harvest times (15%, 12.5%, 10% moisture) than the swathed plots. These lower % vigor results are within the acceptable 20 units of germination therefore maintaining quality parameters. LSD tests (0.05) supports these findings (Table 5).

Table 5. Comparison of mean % vigor of desiccated vs. swathed canola at early, mid, and late harvest times (15%, 12.5%, 10% moisture)

	Mean % Vigor		
Harvest Time	Early (15% H_2O)	Mid (12.5% H_2O)	Late (10% H_2O)
Desiccated	82.75 C	81.75 C	83.50 BC
Swathed	88.25 AB	93.25 A	93.50 A
LSD (0.05)	5.33		
CV (%)	3.82		

* Means followed by the same letter are not significantly different by LSD test (0.05)

Table 6. Climate data summary from swathing to harvest, Hartland, NB, 1999

Date	**Temperature (C°)**		**Precipitation (mm)**
	Maximum	**Minimum**	
***17 - August**	24.9	14.4	1.3
18 – August	21.8	10.9	8.1
****19 – August**	24.1	9.0	0.0
20 – August	25.3	7.1	0.0
21 – August	21.2	10.9	0.0
22 – August	22.0	12.3	0.0
23 – August	27.5	8.8	0.0
24 – August	30.0	11.3	0.0
25 – August	30.3	14.0	0.0
26 – August	30.2	16.0	0.0
27 – August	29.8	15.6	0.0
28 – August	28.3	17.6	Trace
29 – August	22.1	8.1	0.0
30 – August	20.4	5.6	0.0
31 - August	26.1	3.1	0.0

* Swathed
** Desiccated

Conclusion

The preliminary findings suggests that there is potential for the use of desiccants for harvesting canola in New Brunswick. Vigor and % germination of the desiccated canola were lower than the swathed canola however still in the acceptable range to achieve certified standard. By desiccating canola the crop is able to dry down to 10% moisture content at a faster rate than if it was swathed. This is important to New Brunswick producers because of the risk of reducing seed quality due to the wet harvest conditions. Further study in harvest management should be conducted to determine if hybrid canola seed can be desiccated while maintaining seed quality parameters.

Acknowledgments

This project was sponsored by the New Brunswick Soil and Crop Improvement Association with financial assistance from the New Brunswick Department of Agriculture Strategic Partnership Development Fund and Advanta Seeds Inc. from Winnipeg, Manitoba. The authors would like to thank Roy Culberson for providing plot land and seeding equipment for this study.

References

Thomas, P.M. 1999. Canola Growers Manual. Alberta Agriculture, Food and Rural Development, Lacombe, Alberta. www.canola-council.org/index.shtml

Thomas, P.M. 1995. Canola Harvest Management. Alberta Agriculture, Food and Rural Development, Lacombe, Alberta. www.agric.gov.ab.ca/navigation/crops/canola

WINTER AND SPRING CEREAL AND PROTEIN CROP CULTIVAR EVALUATION, HARTLAND, N.B. 1999

ÉVALUATION DE CULTIVARS DE CÉRÉALES D'HIVER ET DE PRINTEMPS ET DE CULTURES PROTÉAGINEUSES HARTLAND (N.-B.) 1999

D.F. Walker[1], A.O.M. Smith[1] and/et P.D. Sandeson[2]

Partner/Partenaire: New Brunswick Soil and Crop Improvement Association/ L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick.

Abstract: The New Brunswick Soil and Crop Improvement Association with funding from the Strategic Partnership Development Program in co-operation with the New Brunswick Department of Agriculture and Rural Development conducted small grain and soybean cultivar evaluation trials at Hartland, N.B. in 1999. In separate replicated small plot trials, 47 lines of spring wheat , 26 lines of six-row barley, 15 lines of two-row barley, 16 lines of normal/naked oats were planted at Hartland on May 4-5. At the same location the Canadian Coop Soybean Variety Trial was planted on May 5 containing 30 entries. There was also a six-row barley screening trial (30 lines) planted at the Hartland site. At Jacksonville, 52 lines of winter wheat were established on Sept. 8, 1998. These trials are part of the Atlantic testing system for small grains and soybeans. In addition to the recognized testing system, a private seed company provided 4 lines of six-row and 2 lines of tow-row barley for evaluation. Data from these trials are used by the Atlantic Field Crop Committee to recommend lines for registration and recommend cultivars for commercial production in Publications 100B and 100D.

Résumé : Des essais de cultivars de petites céréales et de soja ont été réalisés en 1999 à Hartland (N.-B.) par l'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick, grâce à une aide financière accordée par le ministère de l'Agriculture et de l'Aménagement rural du Nouveau-Brunswick dans le cadre du Programme d'établissement de partenariats stratégiques. Quarante-sept lignées de blé de printemps, 26 lignées d'orge à six rangs, 15 lignées d'orge à deux rangs et 16 lignées d'avoine normale à grain nu ont été plantées à Hartland les 4 et 5 mai dans de petites parcelles distinctes répétées. Le 5 mai, on a semé au même endroit 30 variétés inscrites aux essais de variétés de soja de la Canadian Coop Soybean Variety Trial. Trente lignées d'orge à six rangs ont aussi été semées au site de Hartland pour un essai sélectif. Le 8 septembre 1998, on a semé à Jacksonville 52 lignées de blé d'hiver. Ces essais font partie du réseau atlantique d'essais de petites céréales et de soja. En plus du groupe d'essais reconnu, un grainetier a fourni quatre lignées d'orge à six rangs et deux lignées d'orge à deux rangs pour une évaluation. Les données recueillies dans ces essais permettent au Comité des grandes cultures de la région atlantique de recommander des lignées pour l'homologation et des cultivars pour la production commerciale dans les publications 100B et 100D.

Introduction

Plant breeding is the basis for improving the adaptability of crop species or varieties to a specific production area. An essential component of plant breeding is the evaluation of germplasm across the intended area of production. Agriculture Canada has been the organization that has traditionally performed germplasm evaluation in New Brunswick. Agriculture Canada's direct involvement in cultivar evaluation in New Brunswick was terminated at the completion of data analysis in 1995.

---

[1] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB, E3B 5H1 / Direction de l'élevage et de l'alimentation des animaux, MAARNB, Fredericton, NB E3B 5H1

[2] New Brunswick Soil & Crop Improvement Association, Fredericton, NB / L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick, Fredericton, NB

As a result of this decision, there were no plans for cultivar evaluation of early generation material in 1996. This decision meant that the unique environment of the Upper St. John River Valley would not be included in the Atlantic Cultivar Evaluation Testing Program. Cultivars that performed well in this environment would not be added to Publication 100B and 100D. The New Brunswick Soil and Crop Improvement Association recognized the long term damage that could occur if this unique area was not reflected in testing and variety research trials for the Maritimes. The Association in partnership with the Department of Agriculture and Rural Development made the decision to fund and conduct cultivar evaluation trials on winter wheat, 6-row barley, 2-row barley, spring wheat, covered and naked oats and soybeans in 1999.

Materials and Methods

Cereals. On May 4 and 5 of 1999 seven trials, the Maritime six-row barley registration-recommendation test, Maritime six-row barley screening test, Maritime two-row barley registration-recommendation test, Maritime spring wheat registration-recommendation test, Quebec spring feed wheat registration-recommendation test, Quebec spring milling wheat registration-recommendation test, and Maritime covered oat registration-recommendation test, were planted at Hartland, New Brunswick. Private lines of six-row and two-row barley were also tested at the same site in conjunction with the registration-recommendation tests. A Wintersteiger Oyjord plot seeder was used. The seeding rate for all spring wheat, barley, and oat plots was 400, 350 and 350 viable kernels per m^2 respectively. Row spacing was 15 cm (6 row per plot) and plot length was 7.0 meters. Plot design was randomized complete block with three replications. A cyclone spreader was used to apply 90 kg N/ha on May 13. All spring wheat plots received an additional application of 25 kg N/ha on June 28. The fertility source was ammonium nitrate (34-0-0). Dyvel (1.25 L/ha) was applied on May 28 using a Horstine plot sprayer. Plots were harvested with a Hege 140 small plot combine. All barley plots were harvested on August 3. The covered oat plots were harvested August 6. All spring wheat plots were harvested August 10.

Soybeans. A soybean trial, the Canadian Coop registration, was planted at Hartland, New Brunswick on May 5. Plots were 2 x 7 meters. The seeding rate was 80 viable seeds per m^2. Inoculant was added just prior to seeding with Grip. A pre-emerge application of Linuron 480 (2.25 l/ha) was applied with a small plot sprayer. All plots were harvested on September 27 with a Hege 140 plot combine.

Results and Discussion

Winter Wheat. The Winter Wheat Registration-Recommendation Test at Jacksonville was abandoned due to poor winter survival. The Winter Wheat Registration-Recommendation Test Summary (Table 1) includes data from Charlottetown, Canning, Truro and Ottawa and suggests that winter survival was excellent at all other test locations.

Two private varieties, Pioneer 2450 and Pioneer 25R57, were notable due to their high yield (Table 1). However, due to the lack of severe winter conditions at the other four sites, caution should be expressed that these varieties may not survive in N.B.

One variety, WW12-110, a milling line from the Charlottetown Research Center was recommended for registration. Considering that the line has milling qualities, its 9th place rank (Table 1) with a yield of 6.44 T/ha is very acceptable. Most other characteristics including thousand kernel weight, height, winter survival and days to maturity are encouraging. Two weaknesses of WW12-110 are its lodging resistance and test weight.

Spring Wheat. Spring wheat yields were low at the Hartland site ranging from 4.04-3.04 T/ha (Table 2) due to very hot dry conditions during most of the growing season.

AC Wilmot, the most recently recommended variety, continues to show excellent promise and has out yielded the most widely grown variety (Belvedere) for the past several years (Table 2). Agronomic data confirms that AC Wilmot has excellent yield, test weight, thousand kernel weight and maturity. It is now time that N.B. wheat growers make the switch from Belvedere to AC Wilmot.

A new line, AW 305, continues to show promise at the Hartland site as well as all other sites across the region (Table 2). The Atlantic Field Crop Committee recommended AW 305 for registration in Eastern Canada. As seed becomes available of this line, it should be an excellent candidate for N.B. producers. The proposed name for AW 305 is AC Hartland. This line had the highest yielding entry in this test, confirming its high yield potential (Table 2).

Three triticales, AW Grabriel, AC William and Pronghorn, were evaluated in the Quebec Spring Wheat (Feed) Registration-Recommendation Test and yielded very well (Table 3). However, due to disease concerns and late maturity, they are not recommended in N.B

Table 1. Maritime winter wheat reg.-rec. test, Jacksonville, N.B. 1998-99

Cv	Status	Site yrs (yld)	Yield Rank	Yield (t/ha)	Test weight (kg/Hl)	1000 kwt (gm)	Height (cm)	Lodg. (0-9)	Head. (Days)**	Matur. (Days)**	Surv. (%)	Mildew (0-9)	Leaf sept (0-9)
AC CARTIER	c	3	8	6.45	76.5	37.7	93	0.5	9	52	100	0.7	0.9
CASEY	c	3	14	6.20	75.7	37.0	93	0.8	8	50	100	1.5	1.3
FUNDULEA	c	3	16	6.20	80.2	34.7	95	0.0	9	51	99	2.2	0.9
AC WINSLOE	c	3	17	6.16	77.0	33.2	83	1.4	8	51	99	0.6	0.4
BORDEN	c	3	18	6.08	78.3	38.9	114	2.1	10	52	100	1.5	1.1
RUBY	c	3	21	5.98	80.6	38.6	97	0.1	10	50	100	1.6	1.3
KARAT	c	3	25	4.70	80.3	39.7	106	0.1	10	52	99	1.4	1.4
WW 12-105	4	3	9	6.44	77.7	37.2	88	2.3	9	51	100	0.7	0.4
WW 12-110	4	3	11	6.35	77.1	36.2	93	1.4	10	52	100	0.5	0.6
NW 93-35	4	3	13	6.21	78.5	37.7	89	1.2	9	51	99	1.1	0.4
WW 12-100	4	3	15	6.20	76.2	38.5	90	1.2	9	51	100	0.7	0.6
WW 56	3	3	20	6.07	76.4	37.6	91	1.5	9	51	99	0.3	0.5
HANNOVER	3	3	23	5.66	78.0	37.5	91	0.0	9	52	98	1.2	0.9
WW 80	2	3	6	6.51	79.7	36.2	107	1.1	10	52	99	0.5	0.6
WW 76	2	3	24	5.56	78.8	34.5	101	0.9	9	52	100	0.6	0.8
PIONEER 2540	1	3	1	7.16	77.9	35.4	87	1.0	9	50	100	0.4	0.6
PIONEER 25R57	1	3	2	6.92	77.2	34.0	91	0.0	8	50	98	0.6	0.5
AC MACKINNON	1	3	3	6.86	78.0	38.3	94	1.8	9	51	98	0.6	0.6
WW 74	1	3	4	6.59	78.5	35.0	99	0.1	11	52	100	0.4	0.8
WW 72	1	3	5	6.52	78.8	36.5	100	0.1	11	53	99	0.6	1.4
WW 77	1	3	7	6.50	78.9	36.1	100	0.9	10	51	100	0.6	0.4
WW 70	1	3	10	6.42	77.6	37.7	99	0.7	9	51	100	0.9	0.7
96/155	1	3	19	6.08	77.9	44.0	89	0.0	12	55	84	0.5	0.9
AC MORLEY	1	3	22	5.93	80.7	36.3	107	1.6	9	52	100	1.0	0.8
Grand mean				6.24	78.1	36.9	96	0.9	9	51	99	0.9	0.8
SEM				1.331	1.40	4.38	17.6	1.87	9.7	4.7	6.4	1.28	1.41
LSD				3.991	4.19	13.14	52.6	5.61	28.9	14.1	19.1	3.83	4.22

** = DAYS AFTER MAY 31

Table 2. Maritime spring wheat reg.-rec. test, Hartland, N.B. 1999

Cv	Status	Rank	Yield (t/ha)	Test wt (kg/Hl)	1000 kwt (gm)	Height (cm)	Head. (Days)	Matur. (Days)	Protein % (%N*6.25)
AC BARRIE	c	22	3.04	82.9	36.8	76	53	94	16.7
AC NORBORO	c	6	3.75	80.1	37.5	83	53	90	13.6
AC WALTON	c	9	3.63	79.0	37.3	85	56	91	15.3
AC WILMOT	c	3	3.85	82.7	38.0	82	53	92	13.4
BELVEDERE	c	10	3.62	81.4	36.5	83	57	93	13.5
GRANDIN	c	20	3.31	84.5	43.3	79	53	90	15.9
PACIFIC	c	21	3.24	82.9	38.1	87	53	90	16.5
SS BLOMIDON	C	11	3.61	77.7	35.0	82	57	94	15.6
SS MAESTRO	c	15	3.40	77.3	33.5	88	57	95	14.7
SS QUEST	c	12	3.58	79.2	38.0	81	57	94	13.9
AW 305	3	4	3.82	80.4	35.9	86	57	94	14.8
QUANTUM	3	17	3.38	82.9	42.7	78	53	94	15.5
AW 335	2	5	3.79	82.2	35.9	83	56	94	13.0
972-B1	2	13	3.44	79.6	34.5	68	57	95	14.1
972-B5	2	18	3.38	79.2	34.3	71	57	94	13.9
AW 356	1	8	3.73	82.8	39.7	88	56	93	14.1
AW 373	1	2	3.95	82.6	39.7	85	56	91	13.6
AW 375	1	16	3.39	78.0	32.7	76	57	96	13.7
AW 377	1	1	4.04	80.2	34.9	92	56	94	13.3
AW 380	1	7	3.75	82.7	36.0	84	56	94	12.6
M 982-B1	1	14	3.41	78.3	39.2	72	57	93	13.9
M 982-B2	1	19	3.37	75.4	31.2	73	58	94	14.5
Grand mean			3.57	80.5	36.9	81	56	93	14.4
SEM			0.177	0.91	0.97	2.3	0.4	1.3	*
LSD			0.531	2.73	2.90	7.0	1.2	3.8	*
CV			8.497	1.96	4.55	5.0	1.2	2.4	*
Reps			3	3	3	3	3	3	1

Spring Milling Wheat. The Quebec spring wheat (milling) registration-recommendation test (Table 4) was grown in Hartland, N.B. in 1999. Quality data was unavailable at printing, therefore prior to selecting varieties, please consult with Regional Crop Specialist to obtain milling quality data.

Six-row Barley. Spring six-row barley yields ranged from 5.7-3.3 T/ha (Table 5). The hot dry season hastened maturity but did not appear to reduce yield.

The popular variety Chapais still occupies about 90% of the commercial barley acreage. However, Chapais' dominance continues to be challenged by other recommended varieties such as AC Alma, AC Westech and Excel.

One line, AB197-4 was recommended for registration by the Atlantic Field Crop Committee. In terms of numerical rank, 12 lines had higher yields, although statistically there was no difference between the highest yielding cultivar Excel at 5.7 T/ha and AB197-4 at 5.0 T/ha (Table 5).

Although the yield of AB197-4 was low at the Hartland site in 1999, historically across the region it performed much better. If we compare the 3 Maritime sites from 1997-99, it was the number one variety in the region. Given the variability in yield of AB197-4 across years and regions, expectations for this variety are not high.

The four entries submitted by W.G. Thompson & Sons Limited had low and disappointing yields (Table 5).

The Maritime Six-Row Barley Screening trial (Table 6) provides information on early generation lines of six-row barley that may become registered for the Atlantic region. This information is important to N.B. because six-row cultivars are the most widely grown by N.B. grain growers.

Two-row Barley. Two-row barley cultivars normally yield less than six-row cultivars and therefore are not widely grown in N.B. In the future, this could change because kernel size is higher and thresh ability is usually better than the six-row cultivars. Livestock feeders prefer a large kernel with the awn totally removed.

In the future, this could change because two-row cultivars produce more straw than six-row cultivars, kernel size is larger and they are easier to thresh.

There was one hulless line (AB168-11) entered in the Maritime two-row barley registration-recommendation test in 1998 and 1999 (Table 7). Its' yields were much lower than the check lines, however, it might find a niche market on Maritime livestock farms. AB168-11 was recommended for registration by the Atlantic Field Crop Committee.

Normal and Hulless Oats. Normal and hulless oat yield and agronomic data from the Hartland site are included in Table 8.

Although not tested at the Hartland site, the hulless line NO66-4 has shown excellent yield potential in other regions and could have application for N.B. Ontario data indicates that NO66-4 had a 23% yield advantage over other hulless lines. The breeder also advised that it is one of the hairiest lines to date, therefore caution is advised.

Table 3. Quebec spring wheat (feed) reg.-rec. test, Hartland, N.B. 1999

Cv	Status	Rank	Yield (t/ha)	Test wt (kg/Hl)	1000 kwt (gm)	Height (cm)	Head. (Days)	Matur. (Days)
AC GABRIEL	c	3	4.52	78.1	35.0	95	56	92
AC WILLIAM	c	6	3.98	69.3	37.9	101	57	96
MESSIER	c	8	3.75	76.8	36.2	94	56	96
SS FUNDY	c	9	3.69	78.2	31.8	88	57	94
AW 271	2	5	4.36	78.4	32.3	91	55	94
AW 305	2	1	4.65	76.9	35.6	93	55	92
AW 376	1	2	4.54	80.1	32.7	93	56	93
BS 97-310	1	10	3.67	78.8	42.7	94	54	96
CFB 33AA18	1	7	3.88	79.7	38.1	95	55	96
PB 9821	1	11	3.44	75.9	36.6	91	55	96
PB 9826	1	12	3.43	77.7	34.0	97	56	96
PRONGHORN	1	4	4.39	67.3	39.3	98	53	96
Grand mean			4.03	76.4	36.0	94	55	95
SEM			0.204	0.96	0.84	1.6	0.4	0.5
LSD			0.612	2.87	2.51	4.9	1.3	1.5
CV			7.440	2.17	4.02	3.0	1.4	0.9
Reps			3	3	3	3	3	3

Table 4. Quebec spring wheat (milling) reg.-rec. test, Hartland, N.B. 1999

Cv	Status	Rank	Yield (t/ha)	Test wt (kg/Hl)	1000 kwt (gm)	Height (cm)	Head. (Days)	Matur. (Days)
AC BARRIE	c	11	3.53	80.4	35.1	85	53	93
AC BRIO	c	7	3.77	76.8	37.6	88	55	92
AC VOYAGEUR	c	12	3.40	79.4	34.1	98	56	94
SS BLOMIDON	c	9	3.60	74.8	35.9	87	57	93
PB 96-03	3	4	3.93	79.2	40.1	97	54	93
S 14-563.38B	2	5	3.90	81.8	38.1	97	53	92
CFB 97633	2	13	3.10	74.5	32.4	93	58	94
SS QUEST	2	6	3.80	75.8	36.6	86	57	94
AW 364	1	1	4.67	82.3	33.0	93	55	91
AW 373	1	3	4.23	79.9	37.5	88	56	91
AW 381	1	2	4.60	80.1	39.5	93	55	91
S14-597.376S	1	10	3.57	79.0	40.9	92	53	93
CFB 97626	1	8	3.60	76.3	26.3	75	57	92
Grand mean			3.82	78.5	35.9	90	55	92
SEM			0.259	0.49	0.55	1.9	0.3	1.1
LSD			0.777	1.46	1.65	5.6	0.9	3.4
CV			11.743	1.07	2.65	3.6	0.9	2.1
Reps			3	3	3	3	3	3

Table 5. Maritime six-row barley reg.-rec. test, Hartland, N.B. 1999

Cultivar	Yield (T/ha)	Test wt. (kg/Hl)	TKW (g)	Plant ht. (cm)	Days to heading	Days to maturity
Excel	5.7 a	70.9	45.2	81	55	87
AB183-4	5.6 ab	65.9	48.0	85	60	90
AC Westech	5.6 abc	67.8	46.3	86	60	87
AB186-3	5.5 abc	66.2	51.5	86	60	88
CFO38AA66	5.4 abcd	68.1	46.4	85	60	90
AC Alma	5.4 abcd	66.4	49.7	79	60	88
Chapais	5.4 abcd	67.3	50.3	74	60	87
S4181-43	5.3 abcde	68.5	50.7	67	61	87
OBS4840-1	5.3 abcde	67.1	44.9	71	57	87
AB183-5	5.2 abcdef	64.5	45.6	83	60	91
AC Nadia	5.1 abcdefg	69.3	45.5	87	59	87
AB198-2	5.1 abcdefg	67.8	45.9	64	60	87
AB197-4	5.0 abcdefg	70.4	50.4	75	61	87
AC Legend	5.0 abcdefg	69.5	50.1	75	61	90
OBS4728-1	4.9 abcdefg	63.4	46.1	74	54	87
AC Burman	4.9 abcdefg	68.3	42.0	85	57	87
AB189	4.9 abcdefg	64.6	54.8	90	60	88
CFO92033AA18	4.8 bcdefgh	71.0	45.6	78	60	87
Grant	4.7 bcdefgh	67.3	48.4	91	55	88
S4065-125	4.7 bcdefgh	67.2	44.8	66	61	88
C178-005*	4.7 cdefgh	73.2	45.6	73	56	87
C225-001	4.7 cdefgh	71.9	43.6	81	57	87
Stander	4.6 defgh	68.8	44.5	73	58	91
C166-055*	4.6 defgh	69.5	43.9	82	60	87
Beluga	4.4 efgh	64.2	48.9	94	60	91
HYB 328*	4.4 efgh	68.9	44.1	82	61	87
B1602	4.3 fgh	71.5	44.3	82	60	88
CFO35AA1	4.2 gh	64.1	50.3	87	60	91
AB228	3.9 hi	67.6	49.7	86	61	88
C309-010*	3.3 I	69.2	47.7	95	58	87
LSD (.05)	0.9	3.1	3.4	7	2	2
CV (%)	11.0	2.8	4.4	5.1	2.3	1.5

* Entries submitted by W.G. Thompson & Sons Limited

Table 6. Maritime six-row barley screening test, Hartland, N.B. 1999

Cv	Status	Rank	Yield (t/ha)	Test weight (kg/Hl)	1000 kwt (gm)	Height (cm)	Head. (Days)	Matu (Days)
AC WESTECH	c	23	4.88	68.4	42.8	87	59	90
CHAPAIS	c	4	5.63	70.0	53.3	80	59	86
OBS4581-90	1	10	5.41	67.9	47.2	76	59	86
OBS4581-91	1	12	5.26	68.3	43.3	81	58	89
OBS4755-1	1	1	5.87	67.0	50.7	75	60	89
OBS4755-3	1	20	4.96	68.1	53.1	85	60	89
OBS4758-8	1	28	4.49	66.3	50.0	86	60	86
OBS4758-9	1	17	5.15	68.3	44.9	89	57	87
OBS4778-2	1	27	4.56	69.2	43.7	76	59	89
OBS4808-2	1	6	5.59	66.0	48.0	90	57	86
OBS4821-26	1	26	4.75	69.9	43.5	65	60	86
OBS4821-28	1	22	4.93	66.0	47.3	82	59	90
OBS4868-6	1	24	4.84	67.6	48.0	86	59	90
OBS4869-14	1	2	5.73	69.0	43.9	75	59	86
OBS4870-11	1	25	4.83	67.4	48.5	92	59	87
OBS4870-9	1	3	5.72	65.1	48.3	91	59	87
OBS4872-15	1	9	5.42	69.2	50.9	82	58	86
OBS4889-9	1	16	5.16	67.8	48.7	85	59	86
OBS4907-3	1	15	5.24	65.8	48.5	86	59	90
OBS4907-4	1	5	5.59	68.3	51.2	85	59	86
OBS4955-1	1	14	5.24	66.0	46.4	85	59	87
OBS4964-3	1	30	4.33	66.7	50.1	86	60	87
OBS4964-4	1	29	4.38	65.7	50.1	87	60	90
OBS4964-5	1	21	4.95	66.7	46.5	83	59	89
OBS4965-2	1	13	5.26	68.9	52.1	91	60	90
OBS4969-1	1	11	5.38	62.4	43.6	76	59	89
OBS4971-7	1	19	4.98	65.8	45.5	83	59	90
OBS4972-8	1	8	5.43	65.6	44.5	86	58	86
OBS4984-6	1	18	5.13	65.0	47.3	82	59	86
OBS4985-1	1	7	5.53	67.5	49.2	79	59	86
Grand mean			5.15	67.2	47.7	83	59	88
SEM			0.299	0.84	1.39	3.3	0.7	0.8
LSD			0.897	2.53	4.18	10.0	2.0	2.5
CV			9.191	2.17	5.06	6.9	2.0	1.6
Reps			3	3	3	3	3	3

Table 7. Maritime two-row barley reg.-rec. test, Hartland, N.B. 1999

Cultivar	Yield (T/ha)	Test wt. (kg/Hl)	TKW (g)	Plant ht. (cm)	Days to heading	Days to maturity
96/1114	5.4 a	70.5	55.3	84	61	87
983-B2	5.4 a	73.9	56.9	82	61	91
AC Queens	5.3 a	71.0	57.6	93	61	87
Belmore	5.3 ab	73.8	51.6	80	61	87
TO88-061	5.3 ab	73.1	50.4	82	61	87
983-B1	5.1 abc	70.5	54.7	71	62	88
Morrison	5.1 abc	73.4	52.5	81	61	87
AB214-2	5.0 abc	72.6	54.7	87	61	87
AB176-1	4.9 abcd	70.6	54.3	95	61	91
AC Sterling	4.9 abcd	73.0	53.9	84	61	91
AB235-2	4.8 abcde	73.7	53.9	81	61	90
AB166-8	4.8 abcde	70.7	53.2	88	61	87
AB238-2	4.7 bcde	73.1	52.8	79	62	88
Serena	4.7 cdef	72.2	50.4	72	61	88
T193-198*	4.4 def	73.3	50.5	77	61	87
96/1110*	4.2 ef	69.6	45.1	72	61	87
AB168-11**	4.1 f	75.0	46.8	80	62	88
LSD (.05)	0.6	1.6	3.7	5	1	2
CV (%)	7.4	1.4	4.2	3.4	0.7	1.4

* Entries submitted by W.G. Thompson & Sons Limited

** Hulless

Table 8. Maritime oat reg.-rec. test, Hartland, N.B. 1999

Cv	Yield (t/ha)	Test weight (kg/Hl)	1000 kwt (gm)	Heigh (cm)	Head. (Days)	Matur. (Days)	Hull %	Protein %	Oil %
AC BATON	3.75	64.3	31.1	101	53	91	---	21.5	9.44
AC ERNIE	3.28	67.3	22.7	98	59	91	---	21.5	8.15
AC LOTTA	2.92	62.5	29.1	103	49	91	---	20.6	8.47
AC RIGODON	5.01	53.0	30.7	107	56	91	25.17	14.9	7.99
CAPITAL	4.63	50.0	27.1	101	59	90	26.34	14.7	6.19
DONEGAL	4.96	52.6	33.1	102	57	90	26.73	13.7	5.57
NOVA	4.70	52.8	29.9	107	55	90	27.43	15.1	5.94
AC JUNIPER	4.78	56.5	32.7	97	55	90	18.60	14.6	6.70
AC MUSTANG	4.35	50.2	27.9	107	60	92	30.74	14.0	5.55
NORD 1102	4.78	53.0	28.7	100	56	91	27.20	13.7	5.40
TRIPLE CROWN	4.68	53.4	29.1	105	59	91	26.98	15.2	6.19
IRISH	4.39	54.4	31.1	90	53	91	24.67	14.5	5.85
OA 974-1	4.18	50.6	31.1	89	51	90	22.96	14.2	6.52
OA 984-2	4.47	48.2	29.9	93	55	90	27.97	24.3	6.13
OT 792	4.80	49.6	31.1	97	59	92	29.69	13.3	5.18
QO 621.28	4.42	53.8	31.9	109	54	90	26.03	14.3	6.65
Grand mean	4.38	54.5	29.8	100	56	91	26.16	15.6	6.62
SEM	0.152	*	*	2.2	0.4	0.2	*	*	*
LSD	0.454	*	*	6.5	1.2	0.7	*	*	*
CV	5.563	*	*	3.8	1.3	0.4	*	*	*
Reps	3	1	1	3	3	3	1	1	1

Soybeans. Yields of the Canadian Coop Soybean Variety Trial ranged from 3.06-2.36 T/ha (Table 9). It appears that individual soybean traits exhibit wide swings in agronomic characteristics from year to year as affected by weather conditions.

Yield and agronomic stability across years will require more than two years to determine. Because of the year to year variability, it is very difficult to predict the best soybean cultivar. Farmers are advised to plant a number of the highest yielding most agronomically suited cultivars from the recommended list in Publication 100D.

Percent protein and fat are the two most important quality characteristics of soybeans. Table provides preliminary protein and fat data from selected cultivars from the Canadian Coop Soybean Variety Trial. The dry hot growing season produced oil levels 3-4% higher than normal averaging 22% (Table 9).

Table 9. Canadian Coop Soybean Variety Trial, Hartland, N.B. 1999

Name	Yield (kg/ha)	Rank	Days To Mat	100 Seed Wt(g)	Weight per Hectolitre	Prot (%)	Oil (%)
GAILLARD	2367	30	110	15.1	68.9	38.6	22.5
AQUILON	2850	13	119	20.4	68.6	37.3	23.2
ALTA	2779	15	119	18.0	66.8	37.9	22.1
PR9945	2748	16	119	16.2	70.4	38.4	22.5
OAC 99-08	2705	17	119	15.5	69.6	37.8	21.9
OPTIMUS	2627	20	119	16.5	69.5	42.4	20.6
OAC SALEM	2609	22	119	16.1	69.5	39.5	22.8
OT99-10	2563	25	119	16.4	70.1	39.1	22.3
T9404	2527	26	119	18.8	68.8	39.1	22.6
OT98-16	2432	29	119	18.2	66.2	39.5	22.1
PR9901	2973	9	121	18.3	69.4	36.7	21.9
OT99-11	2633	19	124	17.3	70.0	36.3	23.7
OT99-14	3129	2	126	15.9	70.5	36.7	23.0
OT99-13	3073	5	126	17.1	70.0	37.3	22.3
OT99-8	3008	8	126	15.3	68.5	35.9	23.3
OT96-15	2972	10	126	20.1	69.9	38.4	23.1
SECAN 98-32	2847	14	126	18.8	72.0	36.1	23.3
OAC 99-02	2676	18	126	17.8	69.7	33.4	23.8
OT98-14	2619	21	126	17.8	70.5	40.1	20.9
PR9805	2576	24	126	16.5	70.0	40.2	21.4
OT99-12	3306	1	128	17.9	70.8	35.9	23.3
FX9807	3102	4	128	18.3	71.9	37.5	21.3
PS 36	3070	6	128	20.0	70.0	39.2	21.9
OT96-25	3036	7	128	15.7	70.9	36.1	23.4
SECAN 98-33	2866	12	128	17.5	71.5	35.2	21.4
OAC 99-09	2495	28	128	19.2	68.8	37.6	22.3
OT99-9	2506	27	131	19.5	70.2	36.8	23.2
OAC 99-04	3125	3	133	17.2	70.7	36.5	22.7
PH9707	2915	11	133	16.6	72.7	36.7	23.2
AC ORFORD	2604	23	133	17.1	69.1	39.7	21.2
GRAND MEAN	2791		124	17.5	69.9	37.7	22.4
CHECK MEAN	2701		121	17.6	68.9	39.2	22.0
CV	8.34		2.12		1.69		
LSD	257.34		2.81		1.31		
SED	197.72		2.16		1.01		
R2	0.75		0.90		0.76		

Date Planted :
5 May 1999

Conclusions

Cultivar evaluation is extremely important in identifying superior lines of small grains and soybeans. Commercial farmers must be provided with information so they can select the highest yielding most adapted cultivars to grow on their farms. The Hartland trials are a part of the larger testing system providing data from which cultivars are selected for registration and recommendation for Atlantic and Eastern Canada. Cultivar evaluation is important to N.B. farmers and should continue into the foreseeable future.

Acknowledgments

The authors wish to express thanks to the New Brunswick Soil and Crop Improvement Association for providing administrative services for this project. Appreciation is also extended to summer staff Sara Hiscock, Nadine Othberg and Nick Inghram. Funding for this project was provided by the Strategic Partnership Development Fund, Agriculture and Agri-Food Canada, W.G. Thompson and Grand Falls Milling. Roy Culberson provided plot land, land preparation and storage facilities for this project.

EVALUATION OF ROUNDUP TRANSORB ON ROUNDUP READY SOYBEANS GROWN IN NEW BRUNSWICK (1999)

ÉVALUATION DU ROUNDUP TRANSORB SUR LE SOYA ROUNDUP READY CULTIVÉ AU NOUVEAU-BRUNSWICK (1999)

K.V. McCully[1], M. Melanson[1], N. Pothier[1] and/et D.F. Walker[2]

Partners/Partenaires: New Brunswick Soil and Crop Improvement Association and Monsanto / Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick et Monsanto.

Abstract : A trial to evaluate Roundup Transorb applied at various soybean growth stages, with other conventionlly used soybean herbicides were applied on Roundup Ready Soybeans (2601R) grown in Hartland, NB. Visual ratings on crop injury and weed control were collected, as well as yield data. Results indicated that Roundup Ready Soybeans grown in NB were very tolerant to Roundup Transorb regardless of application timing, as injury never exceeded 4% from any of the Roundup Transorb treatments. Roundup Ready Soybeans were also very tolerant to the two standard treatments of Sencor + Dual II Magnum, and Lorox + Dual II Magnum. All the herbicide treatments provided excellent lamb's quarters and wild buckwheat control by the end of the season. Yield data indicated that all the herbicide treatments provided significantly higher yields than the untreated control. Yields for the herbicide treated plots ranged from 3.0 to 3.6 T/ha, but were not significantly different from each other. The untreated control yielded 1.1 T/ha. Overall, Roundup Ready soybeans were found to be extremely tolerant to all the Roundup Transorb treatments and the two standard treatments (Sencor + Dual II Magnum and Lorox + Dual II Magnum). In addition, all the herbicides provided excellent weed control even when applied to larger than recommended weeds.

Résumé : Un essai a été réalisé à Hartland (N.-B.) pour évaluer le Roundup Transorb appliqué à divers stades de développement du soja et d'autres herbicides habituellement utilisés sur le soja Roundup Ready. On a déterminé visuellement l'altération des plants et recueilli des données sur la destruction des mauvaises herbes et le rendement. Les résultats indiquent que le soja Roundup Ready cultivé au Nouveau-Brunswick est très tolérant au Roundup Transorb, sans égard à la période d'application, et que les dommages n'ont jamais dépassé 4 %, quels que soient les taux d'application de Roundup Transorb. Le soja Roundup Ready a aussi été très tolérant aux deux traitements habituels (Sencor + Dual II Magnum et Lorox + Dual II Magnum). Tous les traitements herbicides ont donné d'excellents résultats contre le chénopode et la renouée liseron. Les données sur le rendement indiquent que toutes les parcelles traitées ont donné de bien meilleurs rendements que la parcelle non traitée. Les rendements variaient de 3 à 3,6 t/ha dans les parcelles traitées, mais l'écart n'était pas important entre les diverses parcelles. Le rendement dans la parcelle témoin était de 1,1 t/ha. En général, le soja Roundup Ready s'est révélé très tolérant à tous les traitements de Roundup Transorb et aux deux traitements habituels (Sencor + Dual II Magnum et Lorox + Dual II Magnum). De plus, tous les herbicides ont donné d'excellents résultats contre les mauvaises herbes, mêmes quand ils ont été appliqués sur des espèces plus grandes que celles recommandées.

Introduction

Roundup is a nonselective herbicide that when applied to plant foliage is absorbed and moved throughout the plant tissues. Once inside the plant tissues, the active ingredient in Roundup (glyphosate), inhibits the production of an enzyme required for plant growth and eventually results in plant death. Roundup is considered an environmentally, and user friendly product that generally provides excellent weed control.

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1/ Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

[2] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB / Élevage et alimentation des animaux, MAARNB, Fredericton, NB E3B 5H1

With the introduction of Roundup Ready soybeans, growers now have a new weed management tool available to them. Roundup Ready soybeans have been genetically modified to withstand direct broadcast Roundup applications that would normally kill the crop. As a result it has been suggested that weed control within Roundup Ready crops will be less complex, more flexible, more environmentally friendly, and less costly than within non Roundup Ready soybeans.

To evaluate and demonstrate this relatively new technology, Roundup Ready soybeans were planted in New Brunswick and sprayed with Roundup Transorb at various stages and compared to other conventionally used soybean herbicides.

Materials and Methods

Roundup Ready Soybeans (2601R) were seeded in Hartland, Carleton County with a Wintersteiger Oyjord plot seeder onMay 5th 1999. The seeding rate was 80 seeds/m^2. Spacing between rows was 15 cm. Plot design was a randomized complete block with four replications. Plots were 2m x 7m in size. Grip^{TM} inoculant was added prior to seeding. The soil was a loam with a sand/silt/clay ratio of 28/49/23. The organic matter content and pH was 3.3% and 6 respectively.

The herbicides were applied with a CO_2 handheld sprayer, delivering a water volume of 200 L/ha at a pressure of 207 KPa. The two standard Soybean treatments consisted of Sencor 75DF+ Dual II Magnum, and Lorox 50DF+Dual II Magnum applied pre-emergence on May 19. Roundup Transorb was evaluated and applied to soybeans at three different stages: 2-3 trifoliate (June 24); 5 trifoliate (July 5); and 2-3 trifoliate (June 24) with a sequential application 3 weeks later (July 15) when most soybeans were flowering.

Crop injury and weed control ratings were taken on June 24, July 15, July 22, and August 31. Ratings were taken on a scale 0-100, where 0 represented no weed control or injury, and 100 represented a complete kill. The two predominant weeds found in the plots were lamb's quarters and wild buckwheat.

Within each plot a 1.5 m^2 area was harvested by hand on November 5th, 1999 and yields were adjusted to 13% moisture. All data was subjected to analysis of variance and where the F test was significant at the 5% level, means were separated using the Least Significant Difference test (LSD).

Results and Discussion

In order to evaluate crop tolerance and weed control in Roundup Ready soybeans, Roundup Transorb was applied at either the soybean 2-3 trifoliate leaf stage; the 5 trifoliate leaf stage; or as a sequential application applied first at the 2-3 trifoliate leaf stage, and again at flowering. These treatments were compared to the standard treatments of Sencor + Dual II Magnum, and Lorox + Dual II Magnum applied pre-emergence.

Crop Tolerance. Crop injury ratings taken June 14 and June 24 evaluated the two pre-emergence treatments (Sencor + Dual II Magnum and Lorox + Dual II Magnum) only, as the Roundup Transorb treatments had not yet been applied. Injury from Sencor + Dual II Magnum never exceeded 4% at any time throughout the season (Table 1), and Lorox + Dual II Magnum injury never exceeded 1% any time throughout the season (Table 1). Roundup Ready soybeans were therefore very tolerant to the two standard treatments.

Roundup Ready soybeans were also very tolerant to the Roundup Transorb treatments regardless of timing, or whether 1 or 2 applications were applied. Roundup Ready soybean injury never exceeded 1% at any time throughout the rating period when Roundup Transorb (2.5 L/ha) was applied at the 2-3 trifoliate leaf stage (Table 1), and never exceeded 3% any time throughout the rating period when applied at the 5 trifoliate leaf stage (Table 1). Soybeans were also very tolerant to Roundup Transorb when applied sequentially at the 2-3 trifoliate leaf stage and again at full flower. Injury from this treatment never exceeded 4% anytime throughout the season.

Overall Roundup Ready soybeans were considered very tolerant to the standard herbicide treatments and all the tested Roundup Transorb treatments.

Weed Control. The two most common weeds found at the trial site were lamb's quarters and wild buckwheat. A few smartweed and shepherd's purse plants were also observed but not in high enough densities to rate.

1. Lamb's quarters. Sencor + Dual II Magnum and Lorox + Dual II Magnum both provided 100% control of lamb's quarters throughout the entire season. The Roundup Transorb treatments all provided excellent lamb's quarters control as well, as control was never less than 91% from any of the treatments throughout the season (Table 1). Many of the lamb's quarters plants were larger than recommended (up to 46 cm tall) when sprayed, but were still killed. The larger plants remained upright however, and could still potentially interfere with harvesting. In order to ensure effective burndown and control of lamb's quarters, Roundup Transorb should be applied when lamb's quarters are small. This would generally correspond to soybeans at the 2 to 3 trifoliate leaf stage.

Table 1. Crop injury, weed control ratings and yields data for Roundup Ready Soybean

Treatment	Product rate	Applic. timing	Soybean injury (0-100%)					Weed control (0-100%)						Yields (T/ha) 13% moisture
								Lambs quarters			Wild buckwheat			
			Jun 14	Jun 24	Jul 15	Jul 22	Aug 31	Jun 24	Jul 22	Aug 31	Jun 24	Jul 22	Aug 31	
Untreated Control	-	-	0	0	0a	5	16a	0	0c	0b	0	0c	88b	1.1b
Sencor 75DF+ Dual II Magnum	0.64 kg/ha 15 L/ha	Pre (May 19)	4	0	1a	3	0b	100	100a	100a	98	100a	100a	3.2a
Lorox 50DF+ Dual II Magnum	2 kg/ha 1.5 L/ha	Pre (May 19)	0	0	1a	1	1b	100	100a	100a	100	100a	100a	3.6a
Roundup Transorb	2.5 L/ha	2-3 trifoliates (June 24)	-	-	0a	1	1b	-	96ab	99a	-	80ab	96a	3.3a
Roundup Transorb	2.5 L/ha	5 trifoliates (July 5)	-	-	0a	3	3b	-	91b	100a	-	71b	96a	3.0a
Roundup Transorb; Roundup Transorb	2.5 L/ha + 2.5 L/ha	2-3 trifoliates (June 24) flowering (July 15)	-	-	1a	4	4b	-	99a	100a	-	82ab	96a	3.1a
LSD*			-	-	1.2	N.S. [(1)]	4.6	-	5.4	1.5	-	22	3.8	0.76

* Least Significant Difference

(1) N.S. - not significant

2. Wild buckwheat. Sencor + Dual II Magnum, and Lorox + Dual II Magnum both provided excellent wild buckwheat control throughout the season. Sencor + Dual II Magnum provided wild buckwheat control greater than 98% for the entire season, and Lorox + Dual II Magnum provided 100% control throughout the entire season (Table 1).

Roundup Transorb had a more difficult time controlling wild buckwheat than lamb's quarters. Because of the unusual dry and early spring , wild buckwheat at time of application was more advanced than usual thereby making control more difficult.

At the July 22 rating date the Roundup Transorb treatment resulting in the poorest control was from the application made at the soybean 5 trifoliate leaf stage (71%). At this time, wild buckwheat was large (> 30 cm), thereby making control more difficult. Roundup Transorb applied at the 2-3 trifoliate leaf stage, or as part of the sequential treatment at the soybean 2-3 trifoliate leaf stage resulted in 80 and 82% control respectively (Table 1). The earlier applications were considered more effective as they resulted in a faster burndown as a result of being applied to smaller wild buckwheat plants.

By the final August 31 rating, all treatments including the untreated check provided over 88% control. The reason for the high level of control in the untreated check was the result of heavy insect feeding damage to the leaves, coupled with the thick soybean canopy, and end of season natural die down. All 3 Roundup Transorb treatments provided 96% control, and the Sencor + Dual II Magnum and Lorox + Dual II Magnum both provided 100% control. All the herbicide treated plots resulted in significantly higher wild buckwheat control than the untreated check.

Yields. All the herbicide treated plots resulted in yields significantly higher than the untreated control. Differences between the herbicide treated plots were not significantly different from each other however (Table 1). The highest yielding treatments resulted from Lorox + Dual II Magnum (3.6 T/ha), followed by Roundup 2.5 L/ha applied at the 2-3 trifoliate soybean leaf stage (3.3 T/ha), Sencor + Dual II Magnum (3.2 T/ha), Roundup Transorb applied sequentially at the 2-3 soybean trifoliate leaf stage and again at full flower (3.1 T/ha), and Roundup Transorb 2.5 L/ha applied at the 5 trifoliate soybean leaf stage (3.0 T/ha) (Table 1). The untreated control plot yielded 1.1 T/ha.

Conclusions

Roundup Ready Soybeans were very tolerant to Roundup Transorb (2.5 L/ha) regardless of application timing or whether it was applied one time or two. Injury never exceeded 4% from any of the Roundup Transorb treatments throughout the season. Roundup Ready Soybeans were also very tolerant to the two standard treatments (Sencor + Dual II Magnum, and Lorox + Dual II Magnum) evaluated. All the herbicide treatments provided excellent lamb's quarters and wild buckwheat control. Yield data indicated that all the herbicide treatments provided significantly higher yields than the untreated control. Yields for the herbicide treated plots ranged from 3.0 to 3.6 T/ha, but were not significantly different from each other. Untreated control plots yielded 1.1 T/ha. Overall, Roundup Ready soybeans were found to be extremely tolerant to all the Roundup Transorb treatments and the two standard treatments (Sencor + Dual II Magnum and Lorox + Dual II Magnum). In addition, all the herbicides provided excellent weed control, even when applied to larger than recommended weeds.

Acknowledgements

Appreciation is extended to Anthony Smith (NBDARD) and his summer crew for their assistance with this trial.

STRAW YIELD AND OTHER AGRONOMIC CHARACTERISTICS OF RECOMMENDED SPRING WHEAT, OAT, SIX-ROW AND TWO-ROW BARLEY CULTIVARS, HARTLAND, N.B. 1999

RENDEMENT DE PAILLE ET AUTRES PARTICULARITÉS AGRONOMIQUES DE CULTIVARS RECOMMANDÉS DE BLÉ DE PRINTEMPS, D'AVOINE, D'ORGE À SIX RANGS ET D'ORGE À DEUX RANGS - HARTLAND (N.-B.) 1999

D.F. Walker[1], A.O.M. Smith[1] and/et P.D. Sandeson[2]

Partner/Partenaire: New Brunswick Soil and Crop Improvement Association .and Advanta Seeds Inc./Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick et Advanta Seeds Inc.

Abstract: Straw yield and other agronomic characteristics of spring wheat, oats and barley were compared at Hartland, N.B. in 1999. Straw yields ranged from 8.50-7.19, 6.79-5.69, 7.18-5.69 and 8.42-6.34 T/ha for spring wheat, oats, six-row barley and two-row barley respectively. Plant height ranged from 79-88, 98-107, 66-94 and 72-93 cm respectively for spring wheat, oats, six-row barley and two-row barley. Head population per meter squared ranged from 552-372 for spring wheat, 488-275 for oats, 539-341 for six-row barley and 763-528 for two-row barley. There appears to be little correlation between straw yield, plant height and head population for spring grains. There is an indication that higher head populations can contribute to higher straw yields when comparing two-row and six-row barley.

Résumé : Un essai réalisé à Hartland (N.-B.) en 1999 avait pour but de comparer le rendement de paille et d'autres particularités agronomiques du blé de printemps, de l'avoine et de l'orge. Les rendements de paille variaient de 8,50 à 7,19 t/ha pour le blé de printemps, de 6,79 à 5,69 t/ha pour l'avoine, de 7,18 à 5,69 t/ha pour l'orge à six rangs et de 8,42 à 6,34 t/ha pour l'orge à deux rangs. La hauteur des plants variait de 79 à 88 cm pour le blé de printemps, de 98 à 107 cm pour l'avoine, de 66 à 94 cm pour l'orge à six rangs et de 72 à 93 cm pour l'orge à deux rangs. Le nombre d'épis par mètre carré variait de 552 à 372 pour le blé de printemps, de 488 à 275 pour l'avoine, de 539 à 341 pour l'orge à six rangs et de 763 à 528 pour l'orge à deux rangs. Il ne semblait pas y avoir beaucoup de corrélation entre le rendement de paille, la hauteur des plants et le nombre d'épis pour les grains de printemps. On peut donc en déduire que de plus grandes quantités d'épis contribuent à augmenter les rendements de paille lorsqu'on compare l'orge à deux rangs et l'orge à six rangs.

Introduction

For the past several years an increasing number of grain growers and crop specialists have been asking for information on straw yield and plant height. Straw is becoming a valuable commodity in some parts of the province and can be a significant part of the cash income from grain production. In 1999 straw yield, plant height and several other parameters were collected from most of the recommended cultivars at the Woodstock test site. There is a wide range in straw yields between species and even varieties within species. The crops that gave the highest straw yields were wheat and two-row barley followed by six row barley and oats. We will continue to collect this data and hopefully include winter wheat in 2000.

---

[1] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de l'élevage et de l'alimentation des animaux, MAARNB, Fredericton, NB E3B 5H1

[2] New Brunswick Soil & Crop Improvement Association, Fredericton, NB / Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick, Fredericton, NB

Materials and Methods

On 4 May 1999 four trials, the Maritime spring wheat registration-recommendation test, Maritime oat registration-recommendation test, Maritime six-row barley registration-recommendation test and the Maritime two-row barley registration-recommendation test were planted in Hartland, New Brunswick using a Wintersteiger Oyjord plot seeder. The seeding rates for spring wheat, covered oats and barley were 400, 350 and 350 viable kernels per m^2 respectively. Row spacing was 15 cm (six rows per plot) and harvest area was 7 m^2. Plot design was randomized complete block with three replications. A cyclone spreader was used to apply 90 kg N/ha on 13 May. All spring wheat plots received an additional application of 25 kg N/ha on 28 June. The fertility source was ammonium nitrate (34-0-0). On 28 May Dyvel (1.25 L/ha) was applied using a Horstine plot sprayer. Barley plots were harvested on August 3, covered oats were harvested August 6 and the spring wheat plots were harvested on August 10. All plots were harvested with a Hege 140 small plot combine. A plastic tarp was used to gather the straw from the back of the combine for each of the specified cultivars. The straw was weighed and the weight recorded. For each cultivar, a 1 to 2 kg sample was taken from the first replication and submitted to the laboratory for dry matter analysis. Following harvest, stubble counts were recorded.

Results and Discussion

It is difficult to draw conclusions from one year's data at one location. Therefore, the data is reported in table form and very few conclusions are stated. Straw yield and other agronomic characteristics of spring wheat, oats and barley were compared at Hartland, N.B. in 1999 (Tables 1,2,3,4,5).

There appears to be little correlation between straw yield, plant height and head population for spring grains. There is an indication that higher head populations can contribute to higher straw yields when comparing two-row and six-row barley (Table 5).

Table 1. Straw yield and other agronomic characteristics of spring wheat cultivars, Hartland, N.B. 1999

Cultivar	Straw yield * (t/ha)	Grain yield (t/ha)	Plant height (cm)	Head population/m^2
AW 305	8.62	3.82	86	412
Pacific	8.50	3.24	87	537
SS Quest	8.39	3.58	81	459
AC Walton	8.27	3.63	85	440
AC Norboro	8.23	3.75	83	552
AC Wilmot	8.15	3.85	82	372
Average	8.07	3.58	84	459
SS Blomidon	8.05	3.61	82	468
Belvedere	7.76	3.62	83	391
SS Maestro	7.58	3.40	88	452
Grandin	7.19	3.31	79	504

* straw yield expressed on a dry matter basis; includes leaves, stems, and chaf

Table 2. Straw yield and other agronomic characteristics of covered/hulless oat cultivars, Hartland, N.B. 1999

Cultivar	Straw yield * (t/ha)	Grain yield (t/ha)	Plant height (cm)	Head population/m^2
Triple Crown	6.79	4.68	105	275
AC Baton	6.72	3.75	101	343
Nova	6.41	4.70	107	381
AC Ernie	6.33	3.28	98	345
Capital	6.25	4.63	101	325
Average	6.22	4.24	103	365
Donegal	5.81	4.96	102	356
AC Rigodon	5.75	5.01	107	407
AC Lotta	5.69	2.92	103	488

* straw yield expressed on a dry matter basis; includes leaves, stems, and chaf

Table 3. Straw yield and other agronomic characteristics of six-row barley cultivars, Hartland, N.B. 1999

Cultivar	Straw yield * (t/ha)	Grain yield (t/ha)	Plant height (cm)	Head population/m^2
Excel	7.18	5.58	81	341
Beluga	7.09	4.29	94	399
AC Westech	7.00	5.67	86	539
AC Legend	6.52	4.95	75	479
Average	6.48	5.04	80	436
Chapais	6.19	5.52	74	439
AC Burman	6.15	4.99	85	368
AC Nadia	5.97	4.91	87	407
S4065-125	5.96	4.69	66	560
Stander	5.69	4.44	73	393

* straw yield expressed on a dry matter basis; includes leaves, stems, and chaf

Table 4. Straw yield and other agronomic characteristics of two-row barley cultivars, Hartland, N.B. 1999

Cultivar	Straw yield * (t/ha)	Grain yield (t/ha)	Plant height (cm)	Head population/m^2
AC Queens	8.42	5.26	93	528
Morrison	8.08	5.16	81	677
Belmore	7.76	5.32	80	736
Average	7.50	4.87	82	691
AC Sterling	6.67	4.91	84	763
Serena	6.34	4.73	72	737

* straw yield expressed on a dry matter basis; includes leaves, stems, and chaf

Table 5. Average grain and straw yield of spring cereals, Hartland, N.B. 1999

Cultivar	Straw yield * (t/ha)	Grain yield (t/ha)	Plant Height (cm)	Stubble counts (heads/m^2)
Spring wheat	8.07	3.58	84	459
Two-row barley	7.50	4.87	82	691
Oat	6.22	4.24	103	365
Six-row barley	6.48	5.04	80	436
Average	7.07	4.43	87	488

* straw yield expressed on a dry matter basis; includes leaves, stems, and chaf

Conclusions

Based on one years data, there is a straw yield difference between grain species. There is a strong indication that spring wheat and two-row barley produce higher straw yields than oats or six-row barley. This project will be repeated in 2000 with the addition of winter wheat cultivars.

Acknowledgments

The authors wish to express thanks to the New Brunswick Soil and Crop Improvement Association for providing administrative services for this project. Appreciation is also extended to summer staff Sara Hiscock, Nadine Othberg and Nick Ingram. Funding for this project was provided by the Strategic Partnership Development Fund, Agriculture and Agri-Food Canada, W.G. Thompson and alls Milling. Roy Culberson provided plot land, land preparation and storage facilities for this project.

EVALUATION OF SPRING MILLING WHEAT CULTIVARS FOR ORGANIC PRODUCTION AT SPEERVILLE, DEBEC, HAVELOCK AND SOUTH BRANCH, 1999

ÉVALUATION DE CULTIVARS DE BLÉ DE MOUTURE DE PRINTEMPS POUR UNE PRODUCTION DE TYPE BIOLOGIQUE À SPEERVILLE, DEBEC, HAVELOCK ET SOUTH BRANCH 1999

D.Walker[1], A.Smith[1], J.Scott[2] and/et S.Fleischhaker[2]

Partner / Partenaire: Maritime Certified Organic Growers Co-operative / Co-opératif Certifié Biologique Maritime

Abstract: Yield goals of 1.7 to 2.2 T ha^{-1} and protein quality targets of 13.5% or more were achieved in 1999 spring milling wheat organic cultivar trials carried out in four locations. Wheat yields ranged from1.9 to 2.4 T ha^{-1} in replicated cultivar trials. Milling protein in replicated trials ranged from 12.9 to 14.9%, with most results above 13.5%. The most significant differences in weed and disease pressure were found between locations rather than between cultivars. These evaluations show that it is likely cultivars as good or better than Roblin will be identified over the three year trial period.

Résumé : Les objectifs de rendement de 1,7 à 2,2 t ha^{-1} et de qualité protéique de 13,5 p. 100 ou plus ont été atteints dans les essais de 1999 de cultivars organiques de blé de printemps menés à quatre endroits différents. Les rendements variaient de 1,9 à 2,4 t ha^{-1} dans les essais répétés de cultivars. Le taux de protéine de mouture variait, lui, de 12,9 à 14,9 p. 100, les résultats étant dans la majorité des cas supérieurs à 13,5 p. 100. Les différences les plus importantes entre les pressions exercées par les mauvaises herbes et les maladies ont été relevées entre les endroits plutôt qu'entre les cultivars. Ces évaluations indiquent, selon toute vraisemblance, que des cultivars aussi bons sinon meilleurs que le Roblin seront découverts à la fin de la période triennale d'essais.

Introduction

The demand for locally-grown and organically-grown grains for human consumption has increased dramatically in the 1990s to the point where much of the product has to be imported into the region. A degree of success in growing and processing locally-grown grains has been achieved in New Brunswick, and the industry is ready to grow. One limitation identified by farmers wishing to grow the grains is that available cultivars may not necessarily be the best ones for either New Brunswick conditions or organic farms. This is because, for the most part, they are selected in Western Canada, under conventional management. Farmers were keen to collaborate in selection trials that could identify more appropriate cultivars. In 1999 four certified organic wheat growers hosted wheat cultivar trials.

---

[1] NBDARD, P.O.Box 6000, Fredericton, NB E3B 5H1 / MAARNB, C.P. 6000, Fredericton, NB E3B 5H1

[2] Maritime Certified Organic Growers, c/o 152 Speerville Rd., Speerville, NB E7N 1S2 / Co-opératif Certifié Biologique Maritime, a/s 152, chemin Speerville, Speerville, NB E7N 1S2

It has been demonstrated that local producers have the potential to fill the demand in the region (Walker and Smith, 1989). Farmers, N.B.D.A.R.D. staff, and other researchers, have identified the need for cultivars of milling grains suited to NB/organic growing conditions (Walker and Smith, 1989-1992; William Brinton, *personal communication*). At the same time, millers have identified the need for adequate quality of product for processing.

Yield and Quality of Bread Wheat. In organic systems, yields of 1.7 to 2.2 T ha^{-1} would make wheat crops viable, but commonly about 1.1 T ha^{-1} is achieved with Roblin. Protein levels of 13.5% or more as well as good baking qualities are the goal for millers who buy the wheat from farmers. It is important when seeking higher-yielding cultivars, that they also achieve the quality standards required for commercial mills.

Yields and quality can be improved by cultivar selection, crop management, as well as favourable weather conditions such as dry summer weather (Dormaar *et al.*, 1997; Debaeke *et al.*, 1996). While the weather cannot be controlled, both improved management and selection of appropriate cultivars can help to improve yield and quality.

Cultivars. The cultivars chosen for the trial include Roblin as well as those that are presently being recommended such as AC Walton, AC Barrie, and Grandin. Pollet is a modern cultivar recommended by Quebec organic growers. Cultivars such as Coteau, Teal, and Park that are presently being used and saved by organic farmers were included in the trial. In addition, several ‘heritage’ cultivars (those developed prior to 1950) were included in replicated and non-replicated trials based on seed availability. Heritage cultivars such as Huron, Selkirk, and Acadia are included in the trial because they showed promise during the period when bread wheat was grown extensively in the Maritimes (Nappan Experimental Farm Progress Report, 1953-57; Fredericton Experimental Farm Progress Report, 1953-57; Dr. Hans Nass, *personal communication*). Other heritage cultivars are included because they may contain characteristics useful in breeding programs. The categories of wheat cultivars used in the 1999 trial, which often overlap, are shown in Table 1.

It has been demonstrated that cultivars that do well in organic systems often have different yield rankings than those that do well in conventional systems (Lampkin, 1990; Poutala *et al.*, 1993; Stöppler, 1988). This is not surprising since on organic farms, selection criteria (such as competitiveness with weeds or deep roots) and soil management environments are different from conventional ones. Stöppler (1988) found high yields in organic systems are closely related to high above-ground biomass and high straw yields, and that these factors are associated with greater root penetration and development, which is important for the nutrition of the plant and for anchorage where mechanical weed control is used. In organic systems, the short-strawed wheat cultivars are also disadvantageous because they

Table 1. Categories of spring wheat cultivars used in the 1999 organic trial

Modern cultivars	Cultivars favoured by organic growers	Cultivars developed in the Maritimes	Heritage cultivars
AC Barrie [RS,D,H,B] Grandin [RS,D,H,B] Roblin [RS] Teal [RS,D,H,B] AC Walton [RS,D,H,B]	Coteau [RS] Huron [S] Park [RS] "Speer" [S] Teal [RS,D,H,B] Pollett [RS,D,H,B]	Acadia [RS] AC Walton [RS,D,H,B]	Acadia [RS] Coteau [RS] Huron [S] Red Fife [S] Reward [S] Selkirk [RS]

[RS] included in replicated trial, Speerville site
[S] included in non-replicated trial, Speerville site, due to initial shortage of seed
[D] included in non-replicated trial, Debec site
[H] included in non-replicated trial, Havelock site
[B] included in non-replicated trial, South Branch site

leave the crop open, allowing weeds to compete more effectively and because on most organic farms straw is an important raw material (Lampkin, 1990).

Management. In cultivar trials conducted by Walker and Smith (1989-1992) on organic farms in New Brunswick, yields of 2 T ha^{-1} were achieved in an organic system in 1989 with several cultivars (Walker and Smith, 1989). On this particular farm, manure was applied prior to sowing the wheat crop, and weed management was good. The grain was planted by May 18. Therefore, it is reasonable to assume that yield goals of 1.7 to 2.2 T ha^{-1} are achievable on organic farms in New Brunswick. Unfortunately, protein and other quality indicators were not reported in these organic trials.

Materials and Methods

Speerville Site, Stu Fleischhaker's Farm. Ten spring wheat cultivars (Acadia, AC Barrie, Coteau, Grandin, Park, Pollett, Roblin, Selkirk, Teal, and AC Walton) were planted in 3 x 15m plots with three replicates in a randomized complete block (RCB) design on May 6 using a plot seeder at a rate of 168 kg ha^{-1}. Four additional cultivars (Huron, Red Fife, Reward, "Speer") were planted (on the same day and using the plot seeder) in smaller plots next to the replicated trial for observation and seed increase. The same seeding rate of 168 kg ha^{-1} was used.

The field was manured, plowed, harrowed, and seeded to ryegrass in the spring of 1998, then reworked and seeded to oilseed radish and oats in August, 1998. In the fall of 1998, the field was grazed. On May 4, 1999, the field was lightly disked. No additional fertility or amendments were applied. The soil is a loam. A soil sample taken at seeding indicated an organic matter content of 5.6%, pH of 6.3, medium phosphorous, high calcium and potassium, and adequate magnesium.

Various evaluations of crop seedlings, weeds, and disease were carried out throughout the summer. These observations were made at a fixed location 3 meters from the north edge of each plot, using a 50 x 50 cm quadrat. Samples were taken for disease and biomass evaluation on the edges of the plots so as not to interfere with yield evaluations. A Hedge plot harvester was used to harvest a 1.5 m strip in the middle of each plot on August 17.

Debec Site, William and Joan Flemming's Farm. Five milling wheat cultivars (AC Barrie, Grandin, Pollett, Teal, and AC Walton) were established in unreplicated strips 3 m wide and 93 m long at a rate of 168 kg ha^{-1} on May 5. The rest of the field was planted to AC Walton on the same day.

The soil is a sandy loam and high in fertility due to the lobstermeal added at the time of seeding and the composted manure applied May 4. A soil sample taken at seeding indicated an organic matter content of 3.5%, pH of 6.0, medium phosphorous and calcium, and low levels of potassium and magnesium.

Two samples (50 x 50 cm quadrats) of each cultivar were taken August 3 for disease evaluation. Final yield and biomass estimates on August 16 were taken from 1 x1 m quadrat samples at two corresponding locations in each cultivar strip. The distance into the strip for both of the samples was chosen randomly.

Havelock Site, Bunnett Family Farms. Five milling wheat cultivars (AC Barrie, Grandin, Pollett, Teal, and AC Walton) were established in unreplicated strips 3 m wide and 265 m long at a rate of 168 kg ha^{-1} on May 4. The rest of the field was planted to AC Walton on the same day.

The soil is a sandy loam and high in fertility due to the composted manure applied prior to seeding. A soil sample taken at seeding indicated an organic matter content of 3.1%, pH of 6.3, high levels of phosphorous, calcium, potassium and magnesium.

Two samples (50 x 50 cm quadrats) of each cultivar were taken August 3 for disease evaluation. Final yield and biomass estimates on August 6 were taken from 1 x1 m quadrat samples at three corresponding locations in each cultivar strip. The distance into the strip for the three samples was chosen randomly.

South Branch Site, Peter and Stephanie deGraaf's Farm. Five milling wheat cultivars (AC Barrie, Grandin, Pollett, Teal, and AC Walton) were established in unreplicated strips 6 m wide and 230 m long at a rate of 168 kg ha^{-1} on June 3. The rest of the field was planted to feed wheat on the same day.

The soil is a sandy loam and low in fertility. A soil sample taken at seeding indicated an organic matter content of 3.7%, pH of 5.3, medium phosphorous and calcium, and low levels of potassium and magnesium.

Final yield and biomass estimates on September 7 were taken from 1 x 1 m quadrat samples at two corresponding locations in each cultivar strip. The distance into the strip for both of the samples was chosen randomly.

It should be noted that the Havelock and South Branch sites received far less precipitation than the Speerville and Debec sites. South Branch only received 2-3 cm of rain from planting until maturity.

For all locations, milling protein analysis of composite samples (where applicable) was done at the Charlottetown Research Station, Charlottetown P.E.I.. The results are adjusted to 14% moisture.

Results and Discussion

In organic systems, yields of 1.7 to 2.2 T ha^{-1} and protein levels of 13.5% or more are sought. At the Speerville site (Table 2), where yields were highest of the three locations, yields ranged from 1.9 to 2.4 T ha^{-1}, well within yield goals. All cultivars outyielded Roblin. The highest yielding cultivar was Pollett. In terms of milling protein, only AC Walton, Acadia and Teal would not have been acceptable as they were below 13.5%. Of the ten cultivars studied, there was considerable variation in height. Pollett, Park, and Selkirk were the tallest. Walton and Grandin were the shortest (heights not shown). Grandin appeared to be too short to compete effectively with weeds. Surprisingly seed for AC Barrie, Park and Teal did not germinate as well as others in a test done in May. In the field no similar reduction in germination was observed (data not shown). AC Barrie, Roblin, and Teal all had the lowest incidence of glume *Septoria*; Selkirk, Pollett, and Acadia had the highest. Incidence of *fusarium* ranged from 3 to 12% in sampes, but no cultivars were significantly different from each other due to the high degree of variation. Selkirk and AC Walton had the highest incidence of shriveled kernels.

When results from the four locations are combined (Table 3), we see similar trends. Pollett has the highest yield. All of the cultivars had a milling protein of 13.4% or above; AC Barrie had significantly higher protein results. Pollett and Grandin have significantly larger kernel sizes than the other three cultivars; and Pollett gave the highest straw yield.

Pooled results from three locations (Table 4) show that disease incidence was not significantly different between cultivars, although AC Walton did have the highest incidence of shriveled kernels. Disease incidence did differ between locations. Incidence of *fusarium*, for example, ranged from 0 to 7% at Havelock

Table 2. Replicated spring wheat organic cultivar evaluations (at harvest unless otherwise specified), Speerville, N.B., 1999

Cultivar	Seed germination May (%)	Yield (T ha^{-1})	Milling protein (%)	Spikelets with glume Septoria (%)	Leaf Septoria rating Aug 18 (0-9)	Kernels with *fusarium* (%)	Shriveled kernels (%)
Acadia	75	2.12 a	13.1	56 cde	7 bc	11 a	30 ab
AC Barrie	40	2.15 a	14.1	11 a	5 a	4 a	25 ab
AC Walton	90	2.21 a	12.8	28 b	6 abc	6 a	47 bc
Coteau	90	1.92 a	14.5	47 cd	6 ab	4 a	16 a
Grandin	95	2.08 a	13.8	18 ab	8 c	3 a	10 a
Park	50	1.90 a	14.0	44 c	5 a	5 a	34 abc
Pollett	100	2.36 a	13.4	60 de	7 abc	12 a	37 abc
Roblin	80	1.87 a	14.9	12 a	6 ab	4 a	28 ab
Selkirk	--	2.11 a	13.7	69 e	5 a	7 a	64 c
Teal	65	2.10 a	13.1	12 a	7 abc	4 a	18 a
LSD (0.05)	--	0.50	--	14	1.73	10.2	27.4
CV (%)	--	14.4	--	101	19.5	82.2	58.5

* Means followed by the same letter within each column are not significantly different by LSD test (0.05). LSD is Least Significant Difference, and CV is the coefficient of variation.

Table 3. Spring wheat organic cultivar evaluations at harvest, pooled results from four sites: Speerville, Debec, Havelock and South Branch N.B., 1999

Cultivar	Yield (T ha^{-1})	Milling protein (%)	TKW (g)	Straw yield (T ha^{-1})	Grain heads per m^2
AC Barrie	1.61 b	14.1 a	33.6 c	1.75 ab	300a
AC Walton	1.84 ab	13.4 e	31.9 c	1.80 ab	260 ab
Grandin	1.69 ab	13.7 c	40.3 b	1.62 ab	269 ab
Pollett	1.97 a	13.5 d	44.9 a	1.89 a	220 b
Teal	1.55 b	13.9 b	31.6 c	1.44 b	250 ab
LSD (0.05)	0.35	0.93	2.8	.38	67
CV (%)	25	4	18	32	31

* Means followed by the same letter within each column are not significantly different by LSD test (0.05).

and from 10 to 28% at Debec (data not shown). Only Grandin and Acadia had loose smut, ranging from 0.26 to 0.38 affected heads/m^2 (data not shown). No mildew was observed at any of the locations.

Table 4. Spring wheat organic cultivar evaluations at harvest, pooled results from three sites: Speerville, Debec, and Havelock N.B., 1999

Cultivar	Spikelets with glume Septoria (%)	Leaf Septoria rating Aug 18 (0-9)	Kernels with Fusarium (%)	Shriveled kernels (%)
AC Barrie	33 a	6 a	10 a	22 a
AC Walton	60 a	7 a	9 a	68 b
Grandin	53 a	7 a	10 a	20 a
Pollett	68 a	6 a	10 a	25 a
Teal	66 a	7 a	11 a	31 a
LSD (0.05)	45	3	12	32
CV (%)	59	25	92	72

* Means followed by the same letter within each column are not significantly different by LSD test (0.05).

Biomass evaluations at Speerville (Table 5) indicated that wheat plants make up about 80-90% of the total plant biomass. Only Roblin and Park plants made up less than 80% of the total biomass. Plots sown with Grandin always had the highest percentage of undersown plant biomass at Speerville (Table 5) and when results were pooled (Table 6). This could be because it is shorter and more light filters through the canopy to undersown plants. The highest straw yield at Speerville was produced by Acadia, AC Barrie, AC Walton, Pollett, and Selkirk (Table 5). Pooled results from biomass evaluations (Table 6) showed no significant differences between cultivars.

Conclusions

Separating results out by location shows there is more variation in results between location than between the five modern cultivars evaluated (Table 7). There is also significant variation between years. It is to be expected that when yields of wheat increased at Speerville between 1998 and 1999, protein levels decreased.

Patterns of maturity for the wheat cultivars were noted. Park, Acadia, Roblin, and Selkirk all matured at the same time, several days before the others. The next group to mature was composed of Teal, AC Barrie, and Coteau. The third group, consisting of Grandin and AC Walton, matured even later. Pollett took the longest time to mature but ripened very quickly in the final 7 days before harvest. There were approximately 9-11 days difference in maturity dates between the first group and Pollett.

Pollett appears to have strong yield potential as it had the highest yield at three out of four locations. It is also the tallest cultivar, with the largest-sized kernels.

Table 5. Spring wheat organic cultivar plant biomass evaluations and straw yield at harvest, Speerville N.B., 1999

Cultivar	Wheat plant biomass (% of total)	Weed plant biomass (% of total)	Undersown plant biomass (% of total)	Straw yield (T ha^{-1})
Acadia	83 ab	16 ab	1 b	3.30
AC Barrie	82 ab	14 a	1 b	2.81
AC Walton	84 ab	11 a	3 b	2.72
Coteau	84 ab	10 a	2 b	2.38
Grandin	84 ab	7 a	8 a	2.16
Park	62 b	35 b	1 b	2.20
Pollett	86 a	13 a	1 b	2.73
Roblin	75 ab	20 ab	1 b	2.15
Selkirk	86 a	12 a	1 b	2.68
Teal	88 a	7 a	3 b	1.90
LSD (0.05)	23	23	6	--
CV (%)	15	83	166	--

* Means followed by the same letter within each column are not significantly different by LSD test (0.05).

Table 6. Spring wheat organic cultivar plant biomass evaluations, pooled results from three sites: Speerville, Debec, and Havelock N.B., 1999

Cultivar	Wheat plant biomass (% of total)	Weed plant biomass (% of total)	Undersown plant biomass (% of total)
AC Barrie	73 a	23 a	2 a
AC Walton	74 a	23 a	2 a
Grandin	72 a	20 a	5 a
Pollett	72 a	25 a	3 a
Teal	71 a	22 a	5 a
LSD (0.05)	10.1	9.7	4.3
CV (%)	25.5	72.3	103.9

* Means followed by the same letter within each column are not significantly different by LSD test (0.05).

Pollett, however, takes more time to mature; had a high incidence of *fusarium* relative to other cultivars at Speerville and Havelock; and barely makes the grade for milling protein. Straw yield and wheat plant proportion of crop biomass were both good at all locations, but number of heads/m^2 was consistently the lowest of all locations indicating poor germination, lack of tillering, and/or fewer seeds planted due to larger kernel size.

Milling protein was consistently high in both 1998 and 1999 for AC Barrie (except at South Branch in 1999). This cultivar also had lower overall incidence of disease, as well as respectable yields at all locations except South Branch. AC Walton showed very good yields in most cases, despite the high percentage of

Table 7. Yield, protein, disease and weed pressure of spring wheat cultivars, separated by location, at five sites: Speerville, Debec, Cambridge Narrows, Havelock, and South Branch N.B., 1999 and 1998

Cultivar	Mean wheat yield (T ha^{-1})		Milling protein (%)		Spikelets with glume Septoria (%)		Weed biomass (% of total)	
	1999	1998	**1999**	1998	**1999**	1998	**1999**	1998
Speerville								
AC Walton	**2.20**	1.60	**12.8**	14.1	**28**	31	**11**	46
Grandin	**2.08**	1.11	**13.8**	14.2	**60**	3	**7**	39
Teal	**2.10**	1.12	**13.1**	15.5	**12**	6	**7**	50
AC Barrie	**2.15**	1.48	**14.1**	15.9	**11**	8	**14**	45
Pollett	**2.36**	--	**13.4**	--	**60**	--	**13**	--
Debec								
AC Walton	**1.90**	1.98	**13.3**	13.9	**56**	60	**41**	42
Grandin	**1.70**	2.11	**14.1**	12.6	**42**	n/a	**39**	46
Teal	**1.48**	2.20	**13.7**	11.5	**88**	98	**41**	28
AC Barrie	**1.58**	1.68	**14.9**	13.2	**60**	44	**45**	24
Pollett	**1.46**	--	**13.9**	--	**45**	--	**54**	--
Cambridge-N.								
AC Walton	—	2.43	—	13.4	—	7	—	0
Grandin	—	2.39	—	16.0	—	4	—	0
Teal	—	1.81	—	17.2	—	17	—	0
AC Barrie	—	1.82	—	16.6	—	7	—	0
Pollett	—	--	—	--	—	--	—	--
Havelock								
AC Walton	**1.82**	--	**12.9**	--	**95**	--	**16**	--
Grandin	**1.96**	--	**13.6**	--	**100**	--	**13**	--
Teal	**1.56**	--	**14.0**	--	**98**	--	**19**	--
AC Barrie	**1.96**	--	**14.2**	--	**28**	--	**11**	--
Pollett	**2.28**	--	**13.1**	--	**100**	--	**8**	--
South Branch								
AC Walton	**1.43**	--	**14.7**	--	—	--	**31**	--
Grandin	**1.01**	--	**13.2**	--	—	--	**58**	--
Teal	**1.06**	--	**14.6**	--	—	--	**55**	--
AC Barrie	**0.76**	--	**13.4**	--	—	--	**71**	--
Pollett	**1.79**	--	**13.6**	--	—	--	**34**	--

shriveled kernels. This cultivar is, like Pollett, borderline in terms of making the grade for milling protein.

The heritage wheat cultivars (Acadia, Coteau, Park and Selkirk) evaluated in replicated plots at Speerville appear to have somewhat higher disease incidence than modern cultivars, but not significantly so. Their yields were not significantly different from modern cultivars, and, with the exception of Acadia, their milling proteins were in the high range. They also have the advantage of maturing earlier than most of the modern cultivars. The disease ratings might be better if they were harvested earlier.

Participating farmers indicated a strong interest in continuing with thee trials, and experimenting with mixtures of cultivars that mature at the same time.

Acknowledgements

We would like to thank the farmers, Stu Fleischhaker, William Flemming David and Murray Bunnett, as well as Stephanie and Peter deGraaf who participated in the trials, donated their time and equipment, and shared their expertise. A great deal of assistance and expertise was provided by David Walker, as well as Anthony Smith who was also invaluable in the field. A special thank you is extended to farmers and seed savers associated with Seeds of Diversity Canada, particularly Sharon Rempel, Neall Coulson, Antoine d'Avingon, Francine Mailloux, and David Podoll. Dr. Hans Nass and Dr. Gary Atlin provided critical help. We would also like to thank the New Brunswick Department of Agriculture and Marketing for funding assistance and for the opportunity to form such a constructive partnership.

References

Debaeke, P., Aussenac, T., Fabre, J., Hilaire, A., Pujol, B., and Thuries, L. 1996. Grain nitrogen content of winter bread wheat (*Triticum aestivum* L.) as related to crop management and to the previous crop. *European Journal of Agronomy* 5: 273-286.

Dormaar, J., Luckow, O., Lindwall, C., and Kozub, G. 1997. Effect of artificially eroded Dark Brown Chernozemic soil and subsequent amendments on the milling and baking quality of wheat under dryland conditions. *Canadian Journal of Soil Science* 77: 27-32.

Lampkin, N. 1990. Organic Farming. Farming Press Books, Ipswich, U.K. 616pp.

Poutala,R., Korva, J., and Varis, E. 1993. Spring wheat cultivar performance in ecological and conventional cropping systems. *Journal of Sustainable Agriculture* 3: 63-75.

Stöppler, H. 1988. Zur Eignung von Winterweizensorten hinsichtlich des Anbaues und der Qualität der Produkte in einem System mit geringer Betriebsmittelzufuhr von aussen. PhD Thesis, University of Kassel, West Germany (cited in Lampkin, 1990).

Walker, D. and Smith, A. 1989. Yield and agronomic characteristics of organic grain production 1989. *Adaptive Research Reports* 11: 96-98.

Walker, D. and Smith, A. 1990. Evaluation of triticale / wheat, barley, and oat cultivars under a sustainable production protocol -- Woodstock 1991. *Adaptive Research Reports* **12**: 132-134.

Walker, D. and Smith, A. 1991. Evaluation of spring wheat, oat and hulless oat and barley cultivars under a sustainable production protocol -- Woodstock 1991. *Adaptive Research Reports* **13**: 305-308.

Walker, D. and Smith, A. 1992. Evaluation of spring wheat, oat and hulless oat and barley cultivars under an organic production protocol -- Woodstock 1992. *Adaptive Research Reports* **14**: 257-260.

FORAGE CROPS / FOURRAGES

DEVELOPMENT AND EVALUATION OF FORAGE CROP MANAGEMENT SYSTEMS, NEW BRUNSWICK 1999

MISE AU POINT ET ÉVALUATION DE SYSTÈMES DE GESTION DES CULTURES FOURRAGÈRES – NOUVEAU-BRUNSWICK 1999

M.Price[1], W.Brown[2], A.O.M. Smith[3] and/et Q. Davison[4]

Partner/Partenaire: New Brunswick Soil and Crop Improvement Association/L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick

Abstract: Corn: In on farm corn trials at 3 sites in New Brunswick in 1999 corn maturity levels reflected the high accumulation of CHU's experienced across the Province. The averages for yield and dry matter of the whole plant silage were 12.88 t/ha at 38.0% dry matter in Sussex and 14.2 t/ha at 31.8% dry matter in Grand Falls. The average moisture of the High Moisture Ear Meal in Cornhill was 6.08 t/ha at 25.74% moisture. Managing legumes for forage and silage: In 1997 a series of forage mixtures were established on a beef farm in Norton NB. Data was collected in 1998 however the project was not continued in 1999. Ryegrass seed production: A cultivar evaluation trial to determine the seed yield of 18 varieties of Westerwold annual ryegrass was established in Hartland NB on May 5, 1999. Plots were harvested on three different dates (July 28, August 4, and August 6) with seed yields (t/ha) ranging from 0.25 to 1.12 t/ha. Recommended legume species demonstration: This trial was established in Richmond Corner NB on May 31, 1999. Four species are being evaluated; red clover, white clover, alfalfa, and birdsfoot trefoil. No data was collected during the establishment year. Data collection will commence in the 2000 growing season.

Résumé : Maïs: Des essais de maïs ont été réalisés dans trois fermes du Nouveau-Brunswick en 1999; le maïs a mûri rapidement à cause des températures estivales supérieures à la normale. Les rendements moyens obtenus pour l'ensilage plante entière étaient de 12,88 t/ha avec 38,0 % de matière sèche à Sussex, et de 14,2 t/ha avec 31,8 % de matière sèche à Grand-Sault. Le rendement était de 6,08 t/ha à Cornhill, et la teneur moyenne en eau des épis broyés d'ensilage humide était de 25,74 %. Culture de légumineuses pour le fourrage et l'ensilage: Divers mélanges de plantes fourragères ont été semés dans une ferme bovine de Norton (N.-B.) en 1997. Des données ont été recueillies en 1998, mais diverses circonstances indépendantes de notre volonté ont empêché la collecte de donnée en 1999. Elle devrait reprendre en 2000. Production de semences de raygrass: Le 5 mai 1999, un essai de cultivars a été entrepris à Hartland (N.-B.) pour déterminer le rendement en semences de 18 variétés de raygrass annuel Westerwold. Les parcelles ont été récoltées à trois différentes dates (28 juillet, 4 août et 6 août), et le rendement grainier variait de 0,25 à 1,2 t/ha. Démonstration d'espèces de légumineuses recommandées: L'essai a débuté à Richmond Corner (N.-B.) le 31 mai 1999. Les quatre espèces évaluées étaient le trèfle rouge, le trèfle blanc, la luzerne et le lotier corniculé. Aucune donnée n'a été recueillie durant l'année d'établissement. La collecte des données débutera durant la campagne agricole de 2000.

Introduction

---

[1] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB / Direction de l'élevage et de l'amélioration des animaux, MAARNB, Fredericton, NB

[2] NBDARD, Sussex, NB / MAARNB, Sussex, NB

[3] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB / Direction de l'élevage et de l'amélioration des animaux, MAARNB, Fredericton, NB

[4] New Brunswick Soil and Crop Improvement Association, Fredericton, NB / L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick, Fredericton, NB

Having an adequate supply of top quality forage for pasture and stored feed is one of the top priorities of all livestock producers. To have access to superior plant genetic material is only one part of the equation for successful forage production. Crop management also plays a key role in profitable forage systems and long term sustainability of livestock production in New Brunswick.

Maintaining forage cultivar evaluation trials is imperative. However, there is a need to conduct simultaneous forage management trials aimed at augmenting cultivar evaluation to develop the best management practice(s) for these cultivars. The aim of this initiative is three-fold. First of all the identification of superior forage cultivars will have an overall positive impact on forage yield potential and persistence. Secondly, the development of novel management systems will give the producers a number of choices that can be tailored specifically to their operations. Thirdly, relying on only one commodity makes the N.B. producers vulnerable to market fluctuations and depletes valuable soil resources. Introducing new value added forage crops will help farmers diversify their commodity base, improve soil structure, and aid in the reduction of financial risk which will in turn improve overall farm sustainability and profits.

There were four projects set up under this initiative; an on farm corn demonstration, managing legumes for forage and silage, ryegrass seed production, and a recommended legume species demonstration. The objectives of these projects are as follows:

1) To undertake management studies dealing with improving agronomic and economic returns of high value forage crops.
2) To assess alternate forage crops to provide producers with contingency plans for dealing with adverse environmental conditions such as winterkill.
3) To establish replicated plots at a central location to provide data required to support demonstration sight work established by local SCIA's.

Materials and Methods

Corn. In 1999 corn hybrid demonstration trials were conducted on farms in Cornhill, Sussex, and Grand Falls New Brunswick. The corn hybrids were selected by local seed dealers, NBDARD Field Crop Specialist, and the co-operating farmers. These trials consisted of 10 to 20 hybrids at each site planted in field size plots of 0.15 to 0.2 hectare per hybrid. The trials were planted, sprayed and fertilized using available on-farm equipment. Manure was the main source of nutrients at all farm sites. In 1999 sites were planted between May 18-20th. The whole plant silage site in Sussex was harvested on October 8th and the Grand Falls site on October 5th. High moisture ear corn in Cornhill was harvested on November 23rd.

Managing Legumes for Forage and Silage. This project was established in 1997 but no data was collected during the 1999 growing season.

Annual Ryegrass. A cultivar evaluation of westerwold annual ryegrasses for seed production was established in Hartland on May 5, 1999, using a Wintersteiger Oyjord plot seeder. The experimental design was randomized complete block with three replications. Each variety had a different seeding rate due to variability in seed weight however 500 viable seeds/m2 was used for all varieties. Plot size was 2.0m x 7.0m. Fertility included 150 kg/ha of ammonium nitrate (34-0-0) at seeding and an additional 120 kg/ha at the start of tillering. Plots were sprayed with Buctril M at a rate of 1 L/ha on June 3 for weed control. A Horsestine plot sprayer was used. A 1.0m x 7.0m strip of all plots was harvested with a sickle bar mower. The grass was gathered into burlap bags and hung from a covered, open walled structure for drying. When dry, it was threshed with a Hege 125B combine. Harvest dates and plot yields are shown in Table 6.

Table 1. Annual ryegrass cultivars, Hartland, N.B. 1999

1999 Annual Ryegrass Seed Production Cultivars			
Licherry	Libonus	Barspirit	Jivet
Aubade	Condado	Elunaria	Shoot
Marshall	Jackson	Sabraso	Andy
Spark	Merwester	Barspectra	Barturbo
Lemnos	Portillo		

Recommended Legume Species Demonstration. This trial was established in Richmond Corner NB on May 31, 1999 using a Brillion plot seeder. Four legume species were being evaluated; alfalfa, red clover, birdsfoot trefoil, and white clover. The seeding rates were 12, 11, 12, and 4kg/ha respectively. The experiment was replicated twice in a randomized complete block design. Plot size was 1.5 x 7m. Fertility was applied in the form of 5-10-30 B02 at a rate of 600 kg/ha at seeding and an additional 400 kg/ha on July 6, 1999. Plots were clipped using a sickle bar mower on June 30 and August 10 for weed control. All varieties planted in this trial are shown in table 2. Data collection will begin in the 2000 production season.

Table 2. Recommended legume cultivars, Richmond Corner, N.B. 1999

Alfalfa	Red Clover	BFT	White Clover
AC Caribou	AC Charlie	AC Langille	Milkanova
AC Viva	AC Christie	Bull	Sacramento
Algonquin	AC Endure	Empire	Sonja
Anchor	AC Kingston	Fergus	
Apica	Atlas	Leo	
Arrow	Marino	Upstart	
Centurion	Tempus		
OAC Minto			
Surpass			
Ultra			
5312			
5246			

Results and Discussion

Corn. Publication 100C, "Corn Guide to Hybrid & Pesticide Selection", is the best source available for selecting corn hybrids to grow in the various corn production zones. The hybrids are listed in order of maturity and the zone best suited for their maturity level. Local climatic conditions can have a significant effect on how much heat a farm or field receives in the growing season. On farm trials such as the type reported here can provide information on how the hybrids perform under actual field and local climatic conditions.

1999 was an exceptional year for accumulated heat in New Brunswick with all weather stations reporting CHU's in the range of 400 to 600 above normal. Precipitation also had a better distribution in the midsummer in most locations with the exception of September when the province was visited by a tropical storm. May to the first of August was dry in the Southern Region, which reduced the yield of the earliest maturing hybrids to some extent. In some regions of the Province the dry weather was longer and dryer. At the Sussex site, table 3, yields were high with 8 hybrids yielding over 12.5 t/ha of dry matter and the average was 12.88 t/ha. The maturity level of the hybrids ranged from 2250 to 2600 CHU with even the later maturing hybrids having a reasonable level of dry matter.

Table 3. Whole plant silage, Hazel Hill Farm, Sussex, N.B. 1999

Hybrids	Dry Matter %	Dry Yield t/ha	Dry Yield t/ac	Protein	ADF	TDN
Co-op N16-A2	38.3	12.54	5.07	9.2	24.5	70.6
Mycogen T28121	37.1	14.57	5.90	9.1	24.8	70.4
Hyland HL-2017	33.6	10.55	4.27	9.2	23.8	71.2
Dekalb DK-220	37.6	13.12	5.31	9.5	22.7	71.9
Pioneer 39Y85	35.7	12.57	5.09	8.1	23.9	71.1
Pioneer 39K73	39.6	13.37	5.41	9.2	23.5	71.3
Pioneer 39K72	43.8	12.72	5.15	8.9	25.6	69.8
Pioneer 39J69	35.9	11.83	4.79	8.5	23.5	71.3
Pioneer 39T68	40.5	12.61	5.10	8.0	23.8	71.1
Pickseed Exsile	37.9	14.94	6.05	8.4	25.5	69.9
Average	38.0	12.88	5.21	8.8	24.2	70.9

At the Grand Falls site, table 4, maturity was also exceptional for most of the corn hybrids. This site was harvested on October 5th. The Grand Falls area is normally on the border of zone 4 which is 2100 CHU's, however in 1999 they CHU's were 2565. The dry matter ranged from 28.7 to 37.0 % with only two hybrids below 30 %. Yields here were also high ranging from 12.7 to 16.52 t/ha with an average yield of 14.2 t/ha.

Table 4. Whole plant silage, Laforge Holstein Ltd, Grand Falls, N.B. 1999

Hybrids	Dry Matter %	Dry Yield t/ha	Dry Yield t/ac	Protein	ADF	TDN
Dekalb DK-221	34.1	16.1	6.52	7.6	29.4	67.3
Pickseed Exsile	30.3	15.3	6.19	8.1	29.6	67.1
Dekalb DK-220	30.8	14.8	5.99	8.5	28.7	67.8
Mycogen 2076s	28.7	14.6	5.91	8.3	27.4	68.7
Dekalb DK-183	33.8	14.4	5.83	7.6	29.8	67.0
Co-op N05-H2	30.1	14.4	5.83	8.2	28.4	68.0
Dekalb DK-191	33.8	14.1	5.71	7.9	27.6	68.5
Hyland HL-2017	29.1	13.6	5.50	8.8	25.9	69.7
Pioneer 3984	32.2	13.3	5.38	7.8	33.2	64.6
Pioneer 39K73	33.0	13.3	5.38	7.4	33.2	64.6
Pioneer 39N03	37.0	12.7	5.14	7.7	27.0	68.9
Average	31.8	14.2	5.75	8.0	28.9	67.6

At the Cornhill site, table 5, the plots were harvested as High Moisture Ear Meal using a snapper head on a forage harvester. At this site the harvest was delayed until November 23rd due to an extremely wet fall. Maturity was good here with moisture levels form 22.5 to 31.3 %. All of the hybrids could have been harvested earlier if conditions had permitted. Yields averaged 6.08 t/ha with the top hybrid yielding almost 8 t/ha of dry matter. The delay in harvest this year along with the dry weather in the summer at this site reduced the yield on the earlier hybrids considerably.

Table 5. High moisture ear meal, Waldow Farms, Cornhill, N.B. 1999

Hybrids	Moisture %	Dry Yield t/ha	Dry Yield t/ac	Protein	ADF	TDN
Hyland HL2120	29.6	4.42	1.79	9.2	10.3	80.63
Hyland HL2428	30.6	5.98	2.42	10.1	9.9	80.91
Hyland HL2161	26.8	5.01	2.03	9.4	8.0	82.24
Hyland HLS012	31.3	4.71	1.90	10.1	11.3	79.93
Hyland HL2093	24.6	7.28	2.95	9.6	5.8	83.78
Hyland HL2017	26.9	4.55	1.84	10.0	8.1	82.17
Zeneca 8960	24.8	7.10	2.87	9.8	6.0	83.64
Zeneca N8993	25.2	6.13	2.48	9.9	7.2	82.80
Zeneca 5B124	28.9	6.57	2.66	9.6	10.3	80.63
Zeneca 8975	23.9	7.58	3.07	9.1	6.7	83.15
Zeneca 8985	23.6	6.58	2.66	10.5	6.1	83.57
Pioneer 39J69	25.9	6.23	2.52	9.2	9.8	80.98
Pioneer 39K73	23.9	6.56	2.65	9.0	10.1	80.77
Pioneer 39K72	23.4	6.12	2.48	9.8	7.4	82.66
Pioneer 39T68	25.8	5.85	2.37	9.3	10.3	80.63
Pioneer 39Y85	23.3	7.96	3.22	9.7	10.6	80.42
Dekalb DK-221	22.5	5.31	2.15	9.5	7.2	82.80
Dekalb DK-220	24.4	3.06	1.24	9.9	6.7	83.15
Mycogen 2051	26.7	7.08	2.86	10.3	9.7	81.05
Co-opN16-A2	22.7	7.46	3.02	9.2	11.7	79.65
Average	25.74	6.08	2.46	9.66	8.66	81.78

Annual Ryegrass. Seed production data for this trial is shown below in table 6. Seed yields (t/ha) ranged from 0.25 to 1.12T/ha and germination tests ranged from 66% to 86%. The check varieties for this trial were Aubade and Barspectra. Licherry and Aubade, produced highest seed yields, 1.12 and 1.03T/ha respectively. Portillo, on the other hand, had seed production well below the average (0.25T/ha).

Table 6. 1999 production data for the annual ryegrass seed production trial, Hartland, N.B., 1999

Cultivar	Harvest date, seed yield (t/ha) and germination (%)		
	Harvest date	Yield	Germination
Licherry	July 28	1.12	80
Aubade	July 28	1.03	70
Marshall	July 28	0.98	77
Spark	Aug 4	0.96	86
Lemnos	July 28	0.94	77
Libonus	July 28	0.91	74
Condado	Aug 4	0.63	70
Jackson	Aug 4	0.61	79
Merwester	July 28	0.60	76
Barspirit	Aug 4	0.60	81
Elunaria	Aug 4	0.50	74
Sabraso	Aug 4	0.44	84
Barspectra	Aug 4	0.43	71
Jivet	Aug 6	0.43	70
Shoot	Aug 4	0.34	75
Andy	Aug 4	0.28	75
Barturbo	Aug 4	0.27	66
Portillo	Aug 4	0.25	73
Mean	-	0.63	76
SEM (df=29,n=3)	-		
F prob	-	17.89	2.44
% CV	-	18.78	7.63

Conclusion

Corn. While 1999 was an exceptional year for corn growth, due mainly to the high accumulation of CHU's in the Province, producers should continue to be cautious when selecting new corn hybrids for their planting program . All hybrids in the whole plant silage trials reached satisfactory maturity levels with some in the range where they could have been stored in tower silo's. Producers should not be to quick to move to longer seasons corn hybrids for the majority of their corn crop. While yields of the longer season hybrids are generally higher then the earlier hybrids, frost damage on a hybrid that is not mature will reduce both yield and quality thus significantly reducing the benefits higher yields. There are a number of hybrids that can produce a reasonable yield of High Moisture grain corn in many locations in New Brunswick. These can give livestock producers another option in meeting some of their farms energy requirements by harvesting corn as high moisture ear meal or high moisture grain if a combine is available locally.

Managing Legumes for Forage and Silage. No data was collected from this trial during the 1999 growing season.

Ryegrass Seed Production. Yields from this trial are encouraging. There may be potential profits for producers considering ryegrass seed production. Licherry and Aubade had seed yields in excess of 1.0 T/ha, there were several others cultivars above the 0.9 T/ha plateau. The benefits to growers who take advantage of this are great. They will have an alternate cash crop for their rotations, where situations are suitable there will be an alternate pasture source in the fall for grazing livestock and/or a suitable soil building plow down crop.

Recommended Legume Species Demonstration. Since this was an establishment year, no data was collected. Data collection will commence in during the 2000 growing season.

Acknowledgements

The authors wish to thank the Atlantic Dairy and Forage Institute for the use of the Brillion plot seeder and Haldrup forage harvester.

FORAGE CULTIVAR EVALUATION IN ATLANTIC CANADA, 1999

ÉVALUATION DE CULTIVARS DE FOURRAGE AU CANADA ATLANTIQUE, 1999

M. Price[1], W. Brown[1], A.O.M. Smith[1] and/et Q. Davison[2]

Partner/Partenaire: New Brunswick Soil and Crop Improvement Association/L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick

Abstract: Timothy 1996: Eight cultivars from this trial, TM8501, Colt, AC-Alliance, RVP-03, SF8904, SF8903, SF8607-C and Comtal were superior to check varieties and as a result were supported for registration/recommendation. Annual Ryegrass 1999: Six cultivars from this trial, Magnum, Bellem, Abercomo, Ajax, Max and Fabio were superior to check varieties and as a result were supported for registration/recommendation. Corn Silage and Grain Regionals, Six new grain hybrids & seven new silage hybrids have been added to the Maritime Recommended List. New grain hybrids are Pioneer's 39W54, 39K73, 39M27; Hyland's 2020; Co-op/Novartis' N05-H2 & Dekalb's 308. Newly recommended silage hybrids are Dekalb's 308; Pickseed's ExSile; Co-op/Novartis' G-4066 and Pioneer's 39K73, 39J69, 39Y85 & 39D81. Three Pioneer hybrids (39K73, 39J69, 39M27) are Bt hybrids and have gone on the Recommended List, these offer management options for the regions with serious European corn borer infestations. Trials Established in 199: A series of regional trials were established in 1999. Seven regional variety trials of the following species were seeded at Richmond Corner on May 17; 1998 & 1999 Alfalfa, 1999 Timothy, 1999 White Clover, 1997 Perennial Ryegrass and 1997 Birdsfoot Trefoil. All trials established well. No data was collected from trials in the establishment year, data collection will commence in the 2000 growing season. Two noted exceptions were the annual ryegrass and corn regional trials, these results were summarized and reported in the Forage Evaluator's Report prepared by the Atlantic Field Crops Committee, Cultivar Evaluation Task Group.

Résumé : Fléole 1996 : Huit cultivars soumis à l'essai (TM8501, Colt, AC-Alliance, RVP-03, SF8904, SF8903, SF8607-C et Comtal) étaient supérieurs aux variétés témoins de l'essai, et l'on a appuyé leur homologation ou recommandation. Raygrass annuel 1999: Six cultivars évalués durant l'essai (Magnum, Bellem, Abercomo, Ajax, Max et Fabio) étaient supérieurs aux variétés témoins de l'essai, et l'on a appuyé leur homologation ou recommandation. Essais établis en 1999 : Un groupe d'essais régionaux ont été établis en 1999. Les sept essais régionaux établis à Richmond Corner le 17 mai portaient sur les variétés suivantes : luzerne en 1998 et 1999, fléole en 1999, trèfle blanc en 1999, raygrass vivace en 1997 et lotier corniculé en 1997. Toutes les cultures visées par les essais sont bien établies. Sauf dans le cas de l'essai régional du raygrass annuel, aucune donnée n'a été recueillie durant l'année d'établissement. La collecte des données débutera durant la campagne agricole 2000. Les résultats seront résumés et consignés dans le rapport d'évaluation des fourrages, qui sera rédigé par le groupe de travail sur l'évaluation des cultivars du Comité des grandes cultures de la région atlantique.

Introduction

To be placed on the "Forage Guide to Variety & Mixture Selection", Publication 100A, a cultivar must meet or exceed the yield of the check cultivar for a set number of site years, this varies depending on the perenniality of the species being tested. Data is gathered through a system of Regional trials established at Charlottetown PEI, Nappan and Truro NS, and Fredericton NB. These trials establish the most promising new cultivars available at the time as selected from a breeding and screening trials world-wide.

---

[1] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de l'élevage et de l'alimentation des animaux, MAARNB, Fredericton, NB E3B 5H1

[2] New Brunswick Soil & Crop Improvement Association, Fredericton, NB / L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick, Fredericton, NB

Timothy and Annual Ryegrass are the dominant forage grass grown in Atlantic Canada and as such it is important to have the best cultivars recognized and available for forage producers in the region. Plant breeders are constantly developing new cultivars of timothy that will advance the yield and quality of this forage species over those cultivars presently in production. It is important to evaluate the new material coming from the plant breeders as early as possible in the process to obtain the best cultivars on the market and have them recommended for producers in the Atlantic Provinces.

Materials and Methods

Perennial Grass Trials: 1996. A timothy regional trial consisting of 16 cultivars/lines was established at Fredericton on Aug. 28, 1996 with a Brillion plot seeder. The check cultivars for this trial are Richmond (early), Climax (medium) and Farol (late). The experimental design was randomized complete block with 3 replications. The seeding rate was 11 kg/ha and plot size was 1.25 x 6 meters. No harvest data was collected in the establishment year.

1997. Fertility in 1997 consisted of a broadcast application of 360 kg/ha of 17-17-17 in the spring and 290 kg/ha of 34-0-0 after the first harvest. Harvest dates are reported in Table 5. All plots were harvested with a Haldrup forage harvester.

1998. Fertility consisted of a broadcast application of 550 kg/ha of 15-15-15 .2B in the spring and 175 kg/ha of 34-0-0 after the first harvest. All plots were sprayed with 2-4,D for broadleaf weed control. Harvest dates are reported in Table 6. All plots were harvested with a Haldrup forage harvester.

1999. Fertility in 1999 consisted of a broadcast application of 175kg/ha of 34-0-0 in the spring and 150kg/ha of 34-0-0 after first harvest. Harvest dates are reported in Table 7. All plots were harvested with a Haldrup forage harvester. A timothy regional trial consisting of 8 cultivars/lines was established at Richmond Corner on May 17, 1999 with a Brillion plot seeder. The check cultivars for this trial are Richmond (early), Champ (medium), Climax (medium) and Farol (late).(Table 1) The experimental design was randomized complete block with 3 replications. The seeding rate was 11 kg/ha and plot size was 1.25 x 6 meters. Plots received two application of 15-15-15, the first, 600kg/ha at seeding and second, 300kg/ha, June 30. Plots received 2.0l/ha 2-4D on Aug 13. No harvest data was collected in the establishment year. A perennial ryegrass regional trial consisting of 3 cultivars/lines was established at Richmond Corner on May 17, 1999 with a Brillion plot seeder. The check cultivars for this trial are Mimer Meadow Fescue, Gunne and Bastion Perennial Ryegrass (Table 2). The experimental design was randomized complete block with 3 replications. The seeding rate was 20 kg/ha and plot size was 1.25 x 6 meters. Plots received two application of 15-15-15, the first, 400kg/ha at seeding. Plots received 2.0l/ha 2-4D on Aug 13. No harvest data was collected in the establishment year.

Table 1. Timothy regional trial cultivars, Richmond Corner, N.B. 1999

1999 Timothy Cultivars		
Barliza	Novio	Richmond
Classic	ZPHP91-062	Champ
LoTi 9501	CRS80-118	Climax
LoTi 9502	CRS80-110	Farol

Table 2. Perennial ryegrass cultivars, Richmond Corner, N.B. 1999

1996 Perennial Ryegrass Cultivars		
SW Terry	Bastion	Mimer
Gunne	Feeder	

Perennial Legume Trial: Four cultivar evaluation trials were established in 2000. Legume species being evaluated include the following; 1997 birdsfoot trefoil regional trial, 1998 alfalfa regional trial, 1999 alfalfa regional trial, and 1999 white clover regional trial (Table 3). Alfalfa and birdsfoot trefoil trials were seeded at 12 kg/ha while white clover trials were seeded at 4 kg/ha. Fertility was applied in the form of 5-10-30 $B0_2$ on May 17 at a rate of 600 kg/ha and again on July 6 at 400 kg/ha. All fertilizer was applied with a hand held cyclone spreader. The plots were clipped for weed control on June 30 and July 7. Fusilade was applied to the 1999 alfalfa trial on August 10 at a rate of 2.0L/ha.

Annual Grass Trials: Seeding information. An annual ryegrass trial consisting of 19 cultivars was established in Richmond Corner on May 17, 1999 using a Brillion plot seeder (Table 4). The check cultivars for this trial are Lemtal, a diploid Italian variety, and Aubade, a tetraploid Westerwold variety. The experiment was replicated three times and arranged in a randomized complete block design. Plot size was 1.5 x 7 meters.

Fertility and harvest. Fertility was applied in the form of 600 kg/ha of 10-20-20 at seeding and 150 kg/ha of 15-15-15 on July 6. Following the first two harvests, 34-0-0 was applied at a rate of 150 kg/ha. All fertilizer was applied with a cyclone spreader. A 1.0m x 7.0m strip of all plots was harvested with a sickle bar mower.

Table 3. Perennial legume species established, Richmond Corner, N.B. 1999

Birdsfoot Trefoil 1997	Alfalfa 1998	Alfalfa 1999	White Clover 1999
Leo	Apica	Abby	CRS102
RTF	AC Caribou	C304	HoKv 9275
NB90-102	LRS-93-1	CRS1001	Sacramento
NB89-103	X53V08	DK124	Sonja
LC6F	PS8925MF	DK134	Milkanova
NB90-105	SF9102	DK140	HoKv 9262
NB90-107	53Q60	Magnum IV	LoKv 9601
NB90-109		PS8925MF	
		SF 9012	
		53Q60	
		Apica	
		AC Caribou	

Table 4. Annual ryegrass cultivars, Richmond Corner, N.B. 1999

Annual Ryegrass Cultivars 1999			
Andrea	Lemtal	Ajax	AMPAC-AMI
Magnum	Bellem	Fabio	Barextra
Total	Aubade	Helga	Beatle
Sabroso	Abercomo	SW WR9016	Jivet
Major	Max	Tauro	Major

Results and Discussion

Timothy. First production year data (1997) for the timothy regional trial (1996 seeding) located in Fredericton, N.B. are reported in Table 5. Total dry matter yield (t/ha) for the 1997 harvest season ranged from 11.18 to 9.16 t/ha. Second production year data (1998) are reported in Table 6. Total dry matter yield (t/ha) for the 1998 harvest season ranged from 13.38 to 10.33 t/ha and from 6.68 to 9.7 T/ha in the 1999 harvest season (Table 7). Cumulative yields (Table 8) for over the three year trial period ranged from 9.11 to 10.69 T/ha. Eight cultivars from this trial, TM8501, Colt, Ac-Alliance, RVP-03, SF8904, SF8903, SF8607-C and Comtal were superior to check varieties in this trial and as a result were supported for registration/recommendation. The check cultivars for this trial are Richmond (early), Climax (medium) and Farol (late). Identical trials were also established at Charlottetown, PEI, Truro and Nappan, NS. Summary data from all locations can be found in the Forage Evaluators Report which is prepared annually by the Atlantic Field Crops Committee, Cultivar Evaluation Task Group.

Table 5. First production year data (1997) of the timothy regional trial, Fredericton, N.B. 1997

	Dry matter yield (t/ha) and harvest date				
Cultivar	Harvest date	Cut 1	Harvest date	Cut 2	Total
AC Antoine	June 28	8.44	Aug 25	2.74	11.18
SF8904	July 2	7.77	Aug 25	3.09	10.86
RVP03	July 2	7.71	Sept 19	2.84	10.54
Farol	July 14	7.88	Sept 19	2.62	10.50
Vega	July 2	7.66	Sept 19	2.65	10.30
SF8903	July 2	7.61	Sept 19	2.55	10.16
Carola	July 2	7.54	Sept 19	2.59	10.13
TM8501	July 2	7.04	Aug 17	2.92	9.96
Colt	June 28	7.40	Aug 17	2.49	9.89
AC Alliance	July 2	7.20	Aug 17	2.60	9.80
Climax	July 2	6.77	Aug 25	3.03	9.80
SF8607C	July 14	7.30	Sept 19	2.41	9.71
Tuukka	July 2	7.67	Sept 19	1.98	9.66
SF8307A	June 28	7.36	Aug 17	2.23	9.59
Richmond	June 28	6.45	Aug 17	2.82	9.27
Comtal	July 14	7.26	Sept 19	1.90	9.16
Mean	-	7.44	-	2.59	10.03
SEM (df=29,n=3)	-	0.3	-	0.3	0.526
F prob	-	0.12	-	0.53	0.41
% CV	-	8.4	-	23.4	9.1

Table 6. Second production year data (1998) of the timothy regional trial, Fredericton, N.B. 1998

	Dry matter yield (t/ha) and harvest date				
Cultivar	Harvest date	Cut 1	Harvest date	Cut 2	Total
TM8501	Jun 22	9.57	Aug 10	3.81	13.38
AC Alliance	Jun 29	8.65	Aug 10	4.10	12.75
SF8607C	Jun 22	9.50	Aug 10	3.14	12.64
Richmond	Jun 22	8.33	Aug 10	4.20	12.53
SF8307A	Jun 22	9.18	Aug 10	3.17	12.35
Colt	Jun 22	8.52	Aug 10	3.67	12.19
RVP03	Jun 22	9.08	Aug 10	2.50	11.58
Tuukka	Jun 22	9.10	Aug 10	2.46	11.57
Comtal	Jun 29	9.48	Aug 10	2.07	11.55
Climax	Jun 22	8.88	Aug 10	2.51	11.39
SF8904	Jun 22	8.57	Aug 10	2.77	11.34
Carola	Jun 22	8.76	Aug 10	2.47	11.23
AC Antoine	Jun 22	7.68	Aug 10	3.32	11.00
SF8903	Jun 22	8.97	Aug 10	1.96	10.93
Farol	Jun 22	8.58	Aug 10	2.31	10.89
Vega	Jun 22	9.06	Aug 10	1.28	10.33
Mean	-	8.87	-	2.86	11.73
SEM (df=30,n=3)	-	0.45	-	0.37	0.66
F prob	-	0.35	-	0.00	0.14
% CV	-	8.8	-	22.6	9.7

Table 7. Third production year data (1999) of the timothy regional trial, Fredericton, N.B. 1999

Cultivar	Dry matter yield (t/ha) and harvest date Harvest Date	Cut 1	Harvest Date	Cut 2	Total
SF8607C	June 16	8.62	Sept 10	1.08	9.70
Richmond	June 11	7.70	Sept 10	1.96	9.66
Colt	June 11	7.19	Sept 10	2.27	9.46
SF8904	June 16	8.22	Sept 10	1.13	9.35
SF8307A	June 11	7.65	Sept 10	1.43	9.08
AC Alliance	June 11	6.96	Sept 10	2.07	9.03
Tuuka	June 16	8.06	Sept 10	0.96	9.01
TM8501	June 11	7.13	Sept 10	1.60	8.73
Climax	June 16	7.70	Sept 10	1.00	8.70
RVP03	June 16	7.41	Sept 10	1.03	8.44
SF8903	June 16	7.55	Sept 10	0.84	8.38
Comtal	June 24	7.24	Sept 10	0.95	8.19
Carola	June 11	6.93	Sept 10	0.96	7.89
Farol	June 24	6.73	Sept 10	1.15	7.88
AC Antoine	June 16	6.14	Sept 10	1.46	7.60
Vega	June 11	6.32	Sept 10	0.36	6.68
Mean	-	7.35	-	1.27	8.61
SEM(df=30, n=3)	-	0.504	-	0.260	0.712
F prob	-	0.10	-	0.00	0.24
% CV	-	11.9	-	35.6	14.3

Table 8. Combined data (1997-1998-1999) of the timothy regional trial, Fredericton, N.B. 1999

Cultivar	First cut means		Seasonal means	
	Dry matter (%)	Dry matter yield (t/ha)	Dry matter (%)	Dry matter yield (t/ha)
TM8501	21.6	7.91	24.0	10.69
SF 8607C	24.7	8.47	25.4	10.68
AC Alliance	22.7	7.60	25.3	10.52
SF8904	23.7	8.18	24.9	10.52
Colt	21.2	7.70	23.6	10.52
Richmond	22.0	7.49	24.3	10.49
SF8307A	22.1	8.06	24.0	10.34
RVP03	24.8	8.07	25.7	10.19
Tuuka	23.3	8.28	23.9	10.08
Climax	24.6	7.79	26.0	9.96
SF8903	23.8	8.04	24.7	9.82
Farol	26.4	7.73	26.6	9.76
Carola	21.8	7.74	23.3	9.75
AC Antoine	22.8	7.23	25.0	9.64
Comtal	27.7	8.00	27.8	9.63
Vega	22.9	7.68	23.8	9.11
Mean	23.5	7.88	24.9	10.11
SEM (df=29)	0.61	0.231	0.53	0.404
F prob	0.00	0.07	0.00	0.24
% CV	4.4	5.0	3.6	6.8

Annual Ryegrass 1999. Plots received 160kg/ha N in total, 60kg/ha at seeding and 50kg/ha following each of the first 2 harvests. Plots were only harvested three times in 1999 as below normal precipitation delayed plant growth and decreased yield. Harvest date and yield are shown in table 9. Yields ranged from 5.1T/ha to 7.47T/ha. Yield data showed that six cultivars from this trial, Magnum, Bellem, Abercomo, Ajax, Max and Fabio were superior to check varieties and as a result were supported for registration/recommendation.

Table 9. 1999 production data of the annual ryegrass regional trial, Richmond Corner, N.B. 1999

Cultivar	Dry matter yield (t/ha) and harvest date			
	Cut 1 (Jul 27)	Cut 2 (Sep 8)	Cut 3 (Oct 13)	Total
Ajax	2.83	2.61	2.03	7.47
Tauro	3.12	2.57	1.65	7.33
Barextra	2.88	2.17	2.13	7.18
Sabroso	2.92	2.27	1.83	7.02
Fabio	2.72	2.20	2.09	7.00
Bellem	2.56	2.34	2.01	6.91
Total	2.41	2.28	2.06	6.74
SW WWR9016	2.93	2.01	1.72	6.66
Major	2.95	2.18	1.52	6.65
Magnum	2.87	2.14	1.46	6.47
Abercomo	2.49	1.99	1.99	6.47
Jivet	2.66	1.92	1.86	6.44
Beatle	3.01	2.19	1.24	6.43
Max	2.62	2.01	1.74	6.38
Helga	2.65	1.92	1.79	6.36
Aubade	2.83	1.94	1.50	6.26
Lemtal	2.33	1.82	1.98	6.14
AMPAC-AMI	3.21	1.48	1.08	5.76
Andrea	3.26	1.10	0.74	5.10
Mean	2.80	2.06	1.71	6.57
SEM (df=36,n=3)	0.163	0.188	0.101	0.298
F prob	0.01	0.00	0.00	0.00
% CV	10.1	15.8	10.3	7.9

Corn. The 1999 Maritime corn crop was probably the best ever. Early spring planting conditions and record heat units led to some very fine corn yields and maturity. All areas of the Maritimes were quite dry from May-mid July. Timely rains occurred for most Maritime regions just prior to silking and continued on through to harvest, except for the Annapolis Valley area of Nova Scotia. In western N.S., drought conditions prevailed from late June through to late August, however, in spite of this stress during kernel development, there was good corn yields on the heavier soils in the "Valley" area as well.

Interest in Maritime corn production continues to soar as farmers are excited about the feeding package that both silage and high moisture grain corn offer, plus its productivity under our recent "warming trend", and the protection corn provides against grass forage-drought related shortfalls.

The 1999 Maritime Corn Hybrid Testing program was very active with 42 grain & 38 silage hybrids tested. Highlighting this year's test work was the addition of six new grain hybrids & seven new silage hybrids to the "Maritime Recommended List". These new grain hybrids are Pioneer's 39W54, 39K73, 39M27; Hyland's 2020; Co-op/Novartis' N05-H2 & Dekalb's 308 (Tables 10 & 11) . Newly recommended silage hybrids are Dekalb's 308; Pickseed's ExSile; Co-op/Novartis' G-4066 and Pioneer's 39K73, 39J69, 39Y85 & 39D81 (Tables 12 &13). Three of the Pioneer hybrids (39K73, 39J69, 39M27) are the first Bt hybrids to be added to the Recommended List, and offer a management option for the region's with serious European corn borer infestations.

The corn hybrid testing group is also very optimistic on the potential of 4-5 first year entries in both the silage and grain corn trials, that will hopefully be re-entered next year.

In this year's silage data set, the corn hybrid testing group decided not to include the Charlottetown Silage Trial results due to herbicide damage. This is the second year in a row a silage site has been dropped, so the group is looking into the possibility of adding another Zone 2 site. Having four silage test sites would improve hybrid performance "predictability, but also increase testing fees accordingly

Table 10. Performance data for Sussex grain trial, 1999

HYBRID	Yield @15.5% Moist. (t/ha)	Grain Moist. Content (%)	Stalk Break-age (%)	Emerg-ence (%)	Perfor-mance Index
CHR-448(CHAR-TOWN)	5.77	17.9	5.1	*	76.2
CHR-272(CHAR-TOWN)	7.25	19.8	3.1	*	95.8
39W54 (PIONEER)	8.27	20.0	2.8	*	105.5
96CHR-551 (CHAR-TOWN)	8.65	20.0	5.4	*	105.4
CHR-531(CHAR-TOWN)	7.66	20.6	2.8	*	101.2
N0565 (NK)NOVARTIS	7.81	21.2	4.1	*	102.7
96CHR-539 (CHAR-TOWN)	8.58	21.4	2.0	*	103.7
CHR-559(CHAR-TOWN)	7.60	21.7	5.8	*	100.4
3984 (PIONEER)	7.60	21.9	13.7	*	100.4
PICKSEED 2255	9.13	22.3	2.1	*	102.4
CR9275 (DEKALB)	8.27	22.3	7.8	*	102.4
Z-8985 (ZENECA)	8.31	22.4	1.7	*	102.4
96CHR-516 (CHAR-TOWN)	4.07	22.4	22.3	*	53.8
N03-D9 ELITE(CO-OP)	8.46	22.5	9.4	*	102.2
39T68 (PIONEER)	9.27	22.8	0.8	*	101.8
30A03 ELITE(CO-OP)	7.90	22.9	5.3	*	101.0
HL 2017(THOMPSON)	7.89	23.0	3.2	*	100.9
HL2020 (HYLAND)	9.02	23.0	1.1	*	101.5
39B42 (PIONEER)	7.60	23.1	2.3	*	99.5
N05-H2 (NOVARTIS)	8.43	23.4	2.4	*	101.0
DK308 (DEKALB)	9.11	23.5	0.7	*	100.9
NX1107 (NOVARTIS)	9.59	23.6	0.3	*	100.8
PICKSEED 2299	7.62	23.8	12.1	*	98.7
CR9295 (DEKALB)	8.48	23.8	3.0	*	100.4
K095 (PRIDE)	8.49	23.9	1.9	*	100.4
NX1118 (NOVARTIS)	9.52	23.9	1.4	*	100.3
39K72 (PIONEER)	9.94	24.0	8.1	*	100.1
39K73 (PIONEER)	9.82	24.2	0.1	*	100.0
G-4017 (NOVARTIS)	7.29	24.4	5.1	*	96.3
NX0216 (NOVARTIS)	8.38	24.7	7.2	*	99.2
39A26 (PIONEER)	9.79	24.8	0.0	*	99.1
39M27 (PIONEER)	10.69	24.8	0.0	*	99.1
X0818A (PIONEER)	9.51	25.2	0.6	*	98.6
DK221 (DEKALB)	9.17	25.3	5.8	*	98.5
DK230 (DEKALB)	8.33	25.4	4.4	*	98.3
N-8993 (ZENECA)	9.53	25.6	6.2	*	98.1
DK220 (DEKALB)	8.84	25.6	10.4	*	98.1
X0788DT (PIONEER)	11.32	26.7	1.1	*	96.7
39J69 (PIONEER)	10.03	27.0	2.5	*	96.2
DK307 (DEKALB)	8.48	28.3	1.5	*	94.5
DK335RR (DEKALB)	8.70	28.5	0.1	*	94.2
PICKSEED 2365	8.72	28.7	1.4	*	94.0
LSD(5%)	1.620	2.72	8.52	*	
Grand Mean	8.545	23.58	4.43	*	
C.V.	11.672	7.11	118.50	*	
SEM	0.576	0.97	3.03	*	

Table 11. Grain trials – cumulative performance, 1999

HYBRID	Yield @15.5% Moist. (t/ha)	Grain Moist. Content (%)	Stalk Breakage (%)	Emergence (%)	Performance Index	# Site X Years Tested
CHR-448(CHAR-TOWN)	4.14	26.9	17.9	88.1	65.1	4
39W54 (PIONEER)	7.26	28.1	4.7	89.3	105.0	4
96CHR-551 (CHAR-TOWN)	6.17	28.1	6.0	86.7	97.1	4
96CHR-539 (CHAR-TOWN)	7.17	28.9	7.0	82.4	104.0	4
CHR-272(CHAR-TOWN)	5.38	29.1	5.3	89.3	84.7	4
N0565 (NK)NOVARTIS -	6.46	29.1	12.3	89.5	100.8	56
G-4017 (NOVARTIS) -	6.27	29.2	12.2	88.5	98.7	70
CHR-531(CHR-TOWN)	5.88	29.2	12.7	90.3	92.4	4
3984 (PIONEER) -	6.33	29.2	10.2	91.5	99.7	37
CHR-559(CHAR-TOWN)	6.32	29.8	5.9	81.2	98.9	3
N03-D9 ELITE(CO-OP)	7.51	30.1	0.0	88.9	102.2	4
HL2020 (HYLAND)	6.77	30.1	1.9	88.8	101.5	7
30A03 ELITE(CO-OP)	6.14	30.2	6.6	88.8	96.6	4
CR9275 (DEKALB)	6.11	30.3	9.9	86.0	96.2	4
39K72 (PIONEER)	6.97	30.4	12.6	89.0	101.7	15
Z-8985 (ZENECA)	6.20	30.4	4.2	87.6	97.3	7
PICKSEED 2255	6.61	30.6	3.4	87.9	99.7	10
39T68 (PIONEER)	6.98	30.8	4.0	89.3	101.1	11
96CHR-516 (CHAR-TOWN)	2.27	30.9	18.4	73.4	35.7	4
HL 2017(THOMPSON)	6.71	30.9	3.3	88.5	100.0	15
39B42 (PIONEER) +	6.92	31.0	6.1	91.6	100.8	17
N05-H2 (NOVARTIS)	6.43	31.3	6.0	90.7	97.7	15
PICKSEED 2299 +	6.42	31.4	11.4	86.5	97.4	37
39K73 (PIONEER)	8.52	31.4	0.0	88.0	100.2	7
CR9295 (DEKALB)	7.32	31.7	3.5	90.1	99.9	4
DK230 (DEKALB)	7.04	31.7	5.9	92.4	99.8	15
NX0216 (NOVARTIS)	6.56	31.8	4.3	92.0	97.9	4
DK308 (DEKALB)	8.00	31.8	6.6	90.9	99.6	7
39M27 (PIONEER)	8.33	31.9	0.0	90.1	99.5	7
NX1107 (NOVARTIS)	7.31	31.9	4.5	82.2	99.5	4
K095 (PRIDE)	6.85	32.1	7.6	88.3	99.3	26
DK221 (DEKALB)	7.29	32.2	10.7	92.3	99.1	20
DK220 (DEKALB) +	7.16	32.3	10.9	86.9	99.0	31
X0818A (PIONEER)	8.03	32.3	5.4	89.8	98.9	4
NX1118 (NOVARTIS)	8.95	32.5	0.0	89.3	98.7	4
39A26 (PIONEER)	8.19	32.5	3.5	90.2	98.7	4
DK307 (DEKALB)	8.30	32.9	0.0	92.2	98.0	4
N-8993 (ZENECA)	8.11	33.6	6.0	92.9	97.0	4
39J69 (PIONEER)	9.05	33.7	0.0	86.4	96.9	4
X0788DT (PIONEER)	10.26	34.4	0.3	91.9	95.8	4
PICKSEED 2365	7.48	36.3	2.4	81.0	93.1	4
DK335RR (DEKALB)	7.76	36.6	1.5	85.6	92.7	4

Notes: Early Standard Hybrids indicated by a "-"; Late Standards by a "+".
Emergence recorded before thinning to 33 plants per 7.6 meter row.

Table 12. Performance data for Sussex silage trial, 1999

HYBRID	Yield Whole Plant Dry Matter (t/ha)	Silage Dry Matter (%)	Stalk Breakage (%)	Emergence (%)	Performance Index
CR9275 (DEKALB)	13.74	52.9	2.4	*	82.0
CR9295 (DEKALB)	16.49	51.1	3.8	*	98.5
DK343 (DEKALB)	18.35	49.0	1.5	*	109.6
N05-H2 (NOVARTIS)	15.18	48.9	3.3	*	90.6
DK308 (DEKALB)	15.88	48.6	4.4	*	94.9
PICKSEED 2299	15.26	48.1	0.5	*	91.1
N-8993 (ZENECA)	17.51	48.1	0.4	*	104.6
39W54 (PIONEER)	16.54	48.1	1.2	*	98.8
39M27 (PIONEER)	16.13	47.9	0.1	*	96.3
NX1107 (NOVARTIS)	17.35	47.8	2.3	*	103.6
39T68 (PIONEER)	16.78	47.7	2.7	*	100.2
DK183 (DEKALB)	14.08	47.6	5.4	*	84.1
X0788DT (PIONEER)	19.29	47.1	0.5	*	109.7
DK 191 (DEKALB)	13.49	46.9	13.6	*	80.6
NX1118 (NOVARTIS)	17.90	46.8	2.3	*	106.9
G-4017 (NOVARTIS)	15.61	46.3	9.6	*	93.2
39K73 (PIONEER)	19.43	46.2	0.0	*	107.6
39J69 (PIONEER)	17.72	46.2	1.1	*	105.8
3936 (PIONEER)	18.31	46.0	3.1	*	107.3
39Y85 (PIONEER)	17.38	46.0	0.8	*	103.8
3921 (PIONEER)	21.00	45.9	0.0	*	107.0
39B42 (PIONEER)	17.37	45.9	0.0	*	103.7
X0818A (PIONEER)	17.94	45.8	0.0	*	106.4
HL SX111 (HYLAND)	17.48	45.8	6.0	*	104.3
N06-W9 (NOVARTIS)	15.07	45.7	2.8	*	90.0
DK221 (DEKALB)	17.08	44.8	7.0	*	101.0
EXSILE (PICKSEED)	19.46	44.8	0.8	*	104.4
G-4066 (NOVARTIS)	16.23	44.8	3.9	*	97.0
39D81 (PIONEER)	18.24	44.7	0.0	*	104.2
G-4015 (NOVARTIS)	16.45	44.5	4.6	*	97.7
HL2428 (THOMPSON)	20.39	44.2	5.6	*	102.9
DK307 (DEKALB)	18.61	43.9	0.4	*	102.2
DK220 (DEKALB)	17.26	43.3	3.1	*	99.5
MAXSIL-G(GLENN)	17.58	43.3	8.0	*	100.8
3951 (PIONEER)	17.56	43.0	0.8	*	100.3
HL S012 (HYLAND)	19.68	42.8	1.4	*	99.7
3905 (PIONEER)	17.36	42.4	2.9	*	98.6
39A26 (PIONEER)	17.23	42.1	0.6	*	97.6
DK335RR (DEKALB)	16.92	40.7	0.5	*	94.0
LSD(5%)	2.988	3.60	4.49	*	
Grand Mean	17.215	46.04	2.72	*	
C.V.	10.672	4.81	101.48	*	
SEM	1.061	1.28	1.59	*	

Table 13. Silage trials – cumulative performance, 1999

HYBRID	Dry Matter Yield (t/ha)	Whole-Plant % Dry Matter	Stalk Breakage (%)	Emergence (%)	# of Performance Index	Sites X Years Tested
CR9275 (DEKALB)	9.47	36.5	3.8	81.7	77.8	2
CR9295 (DEKALB)	11.69	35.4	3.9	91.2	96.0	2
DK183 (DEKALB)	10.08	35.3	19.0	89.7	82.7	2
39W54 (PIONEER)	12.02	35.1	3.2	94.0	98.7	2
DK 191 (DEKALB)	11.43	34.8	14.4	93.9	93.8	14
X0788DT (PIONEER)	5.34	34.5	0.0	86.7	112.6	2
39M27 (PIONEER)	11.76	34.2	0.0	87.4	96.6	2
39K73 (PIONEER)	14.97	34.0	1.7	94.9	111.1	2
N05-H2 (NOVARTIS)	11.14	33.8	2.4	91.5	91.4	9
39J69 (PIONEER)	14.91	33.7	0.1	90.7	110.0	2
DK308 (DEKALB)	12.33	33.6	5.8	94.1	101.2	4
DK221 (DEKALB)	13.17	33.2	7.0	93.0	107.9	17
39T68 (PIONEER)	12.34	33.1	1.9	90.8	101.3	7
NX1107 (NOVARTIS)	14.34	33.1	4.7	87.9	108.2	2
DK220 (DEKALB) -	12.49	33.0	6.6	85.8	102.5	22
EXSILE (PICKSEED)	15.15	32.9	7.9	88.4	107.6	4
N-8993 (ZENECA)	12.46	32.3	0.7	85.8	102.0	2
PICKSEED 2299	12.08	32.2	6.7	88.2	99.2	27
G-4015 (NOVARTIS)	13.58	32.1	8.9	89.2	105.0	12
N06-W9 (NOVARTIS)	11.38	32.0	2.7	94.9	93.4	4
G-4066 (NOVARTIS)	13.36	32.0	10.5	91.9	104.6	4
39B42 (PIONEER) -	12.40	31.9	1.3	93.7	100.7	14
39Y85 (PIONEER)	12.51	31.8	2.7	88.6	100.9	4
X0818A (PIONEER)	12.81	31.5	0.6	95.0	101.6	2
3951 (PIONEER) +	12.47	31.3	3.9	90.6	99.6	17
G-4017 (NOVARTIS) -	11.66	31.3	8.1	88.1	95.4	65
DK343 (DEKALB)	13.57	31.1	0.0	86.4	101.7	9
39D81 (PIONEER)	13.89	31.1	2.5	93.6	101.6	4
NX1118 (NOVARTIS)	14.13	31.1	2.1	95.7	101.5	2
3921 (PIONEER)	14.55	30.8	1.7	91.8	100.5	39
3905 (PIONEER) +	13.62	30.5	2.1	91.3	99.8	22
3936 (PIONEER)	13.44	30.4	1.3	88.9	99.3	17
HL2428 (THOMPSON)	14.81	30.1	13.4	93.9	98.3	17
MAXSIL-G(GLENN) +	12.71	29.9	8.8	89.6	97.2	30
DK307 (DEKALB)	14.24	29.9	0.6	91.2	97.7	2
HL SX111 (HYLAND)	13.06	29.4	5.3	93.1	96.1	2
HL S012 (HYLAND)	15.02	29.3	4.3	85.9	95.8	2
39A26 (PIONEER)	13.37	28.8	1.0	85.8	94.1	2
DK335RR (DEKALB)	12.05	25.3	0.1	86.5	81.9	2

Notes: Early Standard Hybrids indicated by a"-"; Late Standards by a "+".
Emergence recorded before thinning to 33 plants per 7.6 meter row.

Conclusion

Timothy. Eight cultivars of timothy, TM8501, Colt, AC-Alliance, RVP-03, SF8904, SF8903, SF8607-C and Comtal have been put forward for registration and/or recommendation.

Annual Ryegrass 1999. Six new Annual Ryegrass cultivars, Magnum, Bellem, Abercomo, Ajax, Max and Fabio, have been supported for registration and/ or recommendation.

Corn. Six new grain hybrids and seven new silage hybrids have been addaed to the "Maritime Recommended List". These new grain hybrids are Pioneer's 39W54, 39K73, 39M27; Hyland's 2020; Co-op/Novartis' N05-H2 & Dekalb's 308. Newly recommended silage hybrids are Dekalb's 308; Pickseed's ExSile; Co-op/Novartis' G-4066 and Pioneer's 39K73, 39J69, 39Y85 & 39D81. Three of the Pioneer hybrids (39K73, 39J69, 39M27) are the first Bt hybrids to be added to the Recommended List.

Trials Established in 1999. Data will be gathered on perennial trials seeded in 1999 for the next three production seasons and assessment will be made on cultivars as to being added to the list of recommended cultivars in Publication 100A.

Acknowledgements

The authors wish to thank the Atlantic Dairy and Forage Institute for the use of the Brillion plot seeder and Haldrup forage harvester.

THE EVALUATION OF ALFALFA CULTIVARS UNDER HAY AND PASTURE MANAGEMENT SYSTEMS

ÉVALUATION DE CULTIVARS DE LUZERNE DANS DES SYSTÈMES D'EXPLOITATION DE FOURRAGE ET DE PÂTURAGE

Y.A. Papadopoulos[1], R. Thériault[2], M.Price[3], K.D.McRae[4], E.A.Clark[5], K.M. Thomas[6], S.A.E. Fillmore[4] and/et E. Charmley[7]

Partner / Partenaire: Moncton Soils and Crops Improvement Association / l'Association pour l'amélioration des sols et cultures de Moncton

Abstract: Alfalfa is an important and reliable hay crop for New Brunswick. In Canada, alfalfa is not generally considered suitable for pasture management. However, studies under Maritime conditions have concluded that alfalfa is capable of superior yield in mixtures under rotational grazing. This study evaluates commercially available alfalfa and new experimental alfalfa synthetics under both hay and pasture management regimes. Ten alfalfa cultivars, including several grazing and hay-type cultivars, were seeded in mixtures with Richmond timothy. Three management regimes were imposed at the Nappan Research Farm: low residual grazing height, high residual grazing height, and hay. Six replicates of the hay treatment were seeded on farm in New Brunswick, three in 1997 and 1998. Over the two dry growing seasons, the pasture management, specifically the high residual grazing height treatment, was the most productive. Over two production years, mixtures containing Apica or Arrow produced more alfalfa on average than the others in the study, regardless of management regime. Alfalfa cultivars selected specifically for grazing were not superior to those selected for general adaptability to New Brunswick soil and climatic conditions.

Résumé: La luzerne est une culture fourragère importante et fiable pour le Nouveau-Brunswick. Au Canada, la luzerne n'est généralement pas considérée utile pour l'exploitation du pâturage. Toutefois, des études effectuées dans les Maritimes ont révélé que la luzerne peut donner un rendement supérieur dans les mélanges qui servent au pâturage tournant. La présente étude avait pour but d'évaluer des espèces de luzerne offertes dans le commerce et de nouveaux types expérimentaux de luzerne dans les systèmes d'exploitation de fourrage et de pâturage. Dix cultivars de luzerne ont été ensemencés dans des mélanges avec la fléole Richmond, et les cultivars comprenaient des espèces destinées au pâturage et au fourrage. Trois systèmes de culture ont été appliqués à la ferme expérimentale de Napan : faible hauteur résiduelle pour le pâturage, grande hauteur résiduelle pour le pâturage,

---

[1] Agriculture and Agri-Foods Canada, CLRC, Charlottetown, PEI C1A 7M8 / Agriculture et agroalimentaire Canada, CRCB, Charlottetown, I-P-É C1A 7M8

[2] Department of Agriculture and Rural Development, Moncton, NB E1C 8R3 / Ministère de l'Agriculture et de l'Aménagement rural, Moncton, NB E1C 8R3

[3] Department of Agriculture and Rural Development, Fredericton, NB E3B 5H1 / Ministère de l'Agriculture et de l'Aménagement rural, Fredericton, NB E3B 5H1

[4] Agriculture and Agri-Foods Canada, AFHRC, Kentville, NS B4N 1J5 / Agriculture et agroalimentaire Canada, AFHRC, Kentville, N.-É. B4N 1J5

[5] University of Guelph, Guelph, ON N1G 2W1 / Université de Guelph, Guelph, ON N1G 2W1

[6] Cumberland County Soils and Crops Improvement Association, Nappan, NS B0L 1C0 / Association pour l'amélioration du sol et des cultures du comté de Cumberland, Nappan, N.-É. B0L 1C0

[7] Agriculture and Agri-Foods Canada, CLRC, Nappan, NS B0L 1C0 / Agriculture et agroalimentaire Canada, CLRC, Nappan, N.-É. B0L 1C0

et fourrage. Les semis ont été répétés six fois dans les essais à la ferme au Nouveau-Brunswick, trois en 1997 et trois en 1998. Durant les deux années de croissance dominées par la sécheresse, le système de pâturage le plus productif a effectivement été celui de la grande hauteur résiduelle pour le pâturage. Durant les deux années de production, les mélanges renfermant les cultivars Apica ou Arrow ont produit plus de luzerne en moyenne que les autres cultivars utilisés dans l'étude, quel que soit le système d'exploitation. Les cultivars de luzerne choisis particulièrement pour le pâturage n'étaient pas supérieurs à ceux retenus pour leur adaptabilité générale au sol et aux conditions climatiques du Nouveau-Brunswick.

Introduction

Although alfalfa is a reliable hay crop in Atlantic Canada, it is not generally considered to be suitable under pasture management in Canada. However, some recent studies indicate that alfalfa is capable of superior yield in mixtures under rotational grazing in the Atlantic region (Thomas, 1990; Rodd et al., 1992). Papadopoulos et al. (1993a and b, 1995) conclude that the performance of cultivars under a clipping management system is not adequate for recommending cultivars for pasture use. Evaluating new cultivars for pasture management under Maritime conditions will help to identify superior cultivars quickly and ensure that future cultivars, including experimental synthetics, will be assessed under pasture. Improving the persistence of alfalfa varieties in hay and/or pasture mixtures is estimated to reduce production cost for the ruminant livestock industry by at least $100 per hectare (Papadopoulos et al., 1993a).

Materials and Methods

Nappan Research Farm. This study was a part of an Eastern Canada trial coordinated by Dr. Ann Clark of the University of Guelph. The Nova Scotia site was the only site that included pasture performance in the trial. Plots were seeded at the Nappan Research Farm on June 15, 1997. The design was a split plot, with whole plots being the three management regimes (two graze, one hay), within which 10 alfalfa and timothy mixtures were randomized.

Ten alfalfa cultivars (supplied by seed trade) were used in the trial, including several "grazing adapted" and standard hay-type cultivars; these provided a range of genetic variability in apparent grazing tolerance. Each cultivar was represented in a mixture with Richmond timothy, a grass likely to be used on-farm, to impose a range of inter-specific competitiveness on the alfalfa. Plots (3 × 6 m) of each mixture within a paddock was sown at a rate of 12:5 kg/ha for alfalfa: timothy. The 10 mixtures were distributed randomly within a solid, square block in each of 12 experimental paddocks, leaving a buffer area around each block which was sown as a complex mixture of all alfalfa cultivars and grass species. The block of plots within each paddock was separated by a buffer of at least 2-3 m from all fences and/or lane-ways, watering facilities, salt/mineral blocks, etc. Weeds were controlled by top clipping in the seeding year (July 29, 1997). Plots were fertilized with 400 kg ha^{-1} of 5-10-30+2B (June 10, 1997) and were fertilized annually with P, K, and lime to soil test.

1. Grazing component. Beginning in the first production year, eight paddocks were allocated to two grazing treatments that imposed a range of stress on the alfalfa. One treatment was a "low" residual height of 5-7 cm maximum. The second treatment was a "high" residual height of 10-12 cm. Paddocks were grazed when the sward height was 20-25 cm. A single "herd" of stock (beef) was used to mob graze through all eight paddocks. Bloat control involved using a monensin bolus. Sward height was measured to ensure cattle would exit the paddocks at the appropriate sward exit height. In both 1998 and 1999, the cattle grazed for three cycles.

Dry matter yield was determined from quadrant samples taken prior to each grazing cycle. Each plot was sampled using two 0.25 m^2 quadrants. Botanical composition was assessed prior to first grazing from a 0.25 m^2 quadrant taken in the centre of each plot. Stand count as alfalfa/m^2 was taken after the first graze when there was sufficient regrowth in the paddock area for species identification. Production year data were collected in 1998 and 1999. During the seeding year (1997) a plant count and botanical composition was determined six weeks after seeding.

2. Hay management component. The remaining four paddocks were managed as a two-cut hay crop as outlined in protocols by the Atlantic Field Crop Committee (AFCC).

For the first and second production year, the hay component was harvested once with a Haldrup plot harvester. Due to the dry growing conditions, there was insufficient regrowth on the hay plots to take a second harvest. Botanical composition was determined prior to harvest and the alfalfa plant count was assessed one week after harvest using a 0.25 m^2 quadrant.

Farm Sites. A randomized complete block design with three replications (three farm sites) was utilized in this experiment; each farm site was considered one replication. Plots were seeded with the above 10 mixtures at Bunnett Farms, Havelock, N.B., Dykestra Farms, Salisbury, N.B., and Johnson Farms, Irishtown, N.B. On each farm, each mixture was seeded in strips of 0.25 ha. Plots on farm sites were managed as a two-cut hay crop as outlined in protocols set by AFCC. Three additional farm sites were seeded in New Brunswick in the spring of 1998 (second seeding at Dykestra and Johnson Farms and one at Henderson Farms in Irishtown, N.B.).

To estimate dry matter (DM) production (yield) all of the plots were harvested once during the seeding year and twice during two production years.

In 1997, Alfalfa plant vigour was rated (1-poor: 5-excellent) and, where possible, DM yield was estimated in the fall of the seeding year. In 1998 the number of alfalfa plants/m^2 was counted one month after seeding, and DM yield and botanical composition were recorded in the fall for all newly seeded plots. In the following two production years, botanical composition was recorded prior to first harvest and the number of alfalfa plants/m^2 following the first harvest. Dry matter yield was assessed further at the second harvest of each season.

Results and Discussion

Nappan Research Farm. The summer of 1997 was exceptionally dry. Average monthly rainfall in July and August was reduced by 50% over the 84-year average. Plots were seeded June 15, 1997. Although there was adequate moisture reserves to allow for seed germination and emergence, seedling growth was very slow and alfalfa seedling numbers were lower than normal: 34 to 46 plants m^{-2} (Table 1). Timothy seedlings were also slow to establish. All plots appeared to recover from drought stress by the fall. Hay plots were assessed for DM production on July 21. Mean DM yield differences were observed among the tested cultivars; the highest yielding alfalfa cultivar 8920 produced 0.63 t ha^{-1} and the lowest yielding cultivar, Able, only 0.24 t ha^{-1}. Yields of timothy at the time of harvest were very low with plot means of only 0.02 t ha^{-1}. Weed yields were significant at 0.65 t ha^{-1} (Table 1); the area was clipped immediately following sampling and the resulting regrowth appeared to be free from competing weeds.

The 1998 growing season differed from 1997 with a warm, early spring and little frost from the preceding winter. These conditions, along with adequate and timely moisture, contributed to good spring growth. The first cycle of grazing by cattle started June 3. Two additional grazing cycles were completed, the first on July 21 and the second on September 15. Normally, one could expect one or two additional grazing cycles/seasons, but in July and August precipitation was below normal and both the mean temperature and number of sunshine hours were above average. The resulting dry field conditions limited crop regrowth in July through August, with only one hay harvest at Nappan (June 25). Management (hay or pasture) had a significant effect on total yield (Table 2). Total yields under high residual pasture management were significantly greater than those from hay and low residual pasture management (5.05 t/ha vs. 3.92 t/ha and 3.89 t/ha) (Table 2).

Botanical analysis revealed no significant management effect nor cultivar by management interaction, but there were significant cultivar differences (Table 2). Generally, Apica and Arrow produced more alfalfa on average, irrespective of management. Able and 94GG consistently produced lower than average levels of alfalfa. Levels of production of the remaining two components (Timothy and other species) were not affected by cultivar nor management (Table 2).

The 1999 growing season was very similar to 1998. Warm temperatures were

Table 1. Seeding year results from hay management plots at the Nappan Research Farm in 1997

Cultivar (Cv)	Dry Matter Yield (t/ha)				Plants/m^2
	Seasonal	Alfalfa	Timothy	Other	
AC Caribou	1.16	0.40	0.01	0.75	43
Apica	1.14	0.53	0.01	0.60	40
OAC Minto	1.13	0.48	0.08	0.57	37
94GG	0.92	0.38	0.01	0.53	42
Arrow	1.03	0.54	0.01	0.48	40
8920	1.33	0.63	0.05	0.65	43
Able	1.07	0.24	0.00	0.83	42
Alfa-graze	1.33	0.59	0.01	0.73	45
Spreader3	1.21	0.40	0.01	0.80	34
Prowler1	1.16	0.53	0.03	0.60	46
Grand mean	1.15	0.47	0.02	0.65	41
SEM	0.053	0.052	0.013	0.058	9.0
F pr. (Cv)	<0.001	<0.001	0.00	0.00	0.89
%CV	16	38	211	31	44

accompanied by less than average rainfall. The hay plots were harvested for first cut on June 24. There was not sufficient regrowth throughout July and August to take a second cut. The grazing paddocks had sufficient growth for three cycles throughout the season: June 9, July 28, and Sept 13. The results of the second production year (Table 3) indicate an increase in mean seasonal yield from 4.29 t/ha in 1998 to 5.80 t/ha in 1999. The alfalfa cultivars show a significant difference in yield when management methods are compared. The pasture yields of high and low residue at 6.39 and 5.50 t/ha, respectively, are much greater than the hay mean yield of only 2.00 t/ha. Part of this difference is due to the fact that only one hay harvest was collected in comparison with three grazing regimes on the pasture treatments. The density of the alfalfa on plots was also affected by specific management regimes (Table 3). The pasture management treatments are consistent with a stand count of 18 plants/m^2. Conversely, the hay management plots have a much larger alfalfa count at 39 plants/m^2.

For yields of alfalfa at the Nappan site, regardless of management regime, Apica and Arrow produced more alfalfa on average than other cultivars (Table 4).

Table 2. First production year results of various alfalfa varieties under hay and pasture management at the Nappan Research Farm in 1998

Harvest Method	Cultivar (Cv)	Dry Matter Yield (t/ha)				Plant #/m^2
		Total	Alfalfa	Timothy	Other	
Low Residue (5-7cm)	AC Caribou	3.75	2.19	0.86	0.70	37
	Apica	4.55	2.85	1.28	0.42	21
	OAC Minto	4.23	2.60	0.96	0.68	34
	94GG	4.02	2.36	0.95	0.71	40
	Arrow	3.76	1.90	1.04	0.82	27
	8920	3.37	2.10	0.36	0.91	29
	Able	3.63	1.84	0.52	1.27	26
	Alfa-graze	4.27	1.70	0.78	1.80	31
	Spreader3	3.02	0.19	1.42	1.41	29
	Prowler1	4.32	2.00	0.40	1.92	30
	Mean	*3.89*	*1.97*	*0.86*	*1.06*	*30*
High Residue (10-12cm)	AC Caribou	5.14	3.11	0.52	1.52	37
	Apica	5.38	4.07	0.62	0.70	41
	OAC Minto	5.18	3.18	0.95	1.04	19
	94GG	5.00	2.58	0.97	1.46	22
	Arrow	5.54	4.21	0.44	0.90	34
	8920	4.78	3.32	0.56	0.91	46
	Able	5.09	2.44	1.92	0.72	34
	Alfa-graze	4.65	2.78	0.51	1.36	19
	Spreader3	4.91	3.72	0.52	0.67	44
	Prowler1	4.84	3.67	0.83	0.34	37
	Mean	*5.05*	*3.31*	*0.78*	*0.96*	*33*
Hay	AC Caribou	3.82	2.69	0.29	0.83	31
	Apica	3.97	3.20	0.39	0.38	35
	OAC Minto	4.24	2.79	0.69	0.75	27
	94GG	3.61	1.23	0.74	1.64	19
	Arrow	3.92	2.95	0.67	0.42	40
	8920	4.24	3.22	0.33	0.68	37
	Able	3.64	1.82	0.53	1.29	24
	Alfa-graze	4.27	2.22	1.10	0.95	22
	Spreader3	3.86	2.40	0.47	1.22	25
	Prowler1	3.65	2.41	0.51	0.73	18
	Mean	*3.92*	*2.49*	*0.57*	*0.89*	*28*
Grand Mean		4.29	2.59	0.74	0.97	30
SEM (Cv*Method)		0.430	0.770	0.382	0.410	10.3
F pr.(Method)		0.023	0.294	0.642	0.791	0.821
F pr.(Cv)		0.377	0.035	0.596	0.231	0.659
F pr.(Cv*Method)		0.532	0.409	0.204	0.298	0.563
%CV		16	42	90	80	56

Table 3. Second production year results of various alfalfa varieties under hay and pasture management at the Nappan Research Farm in 1999

Harvest Method	Cultivar	Dry Matter Yield (t/ha)			Plant #/m^2
		Total	Alfalfa	Timothy	
Low Residue (5-7cm)	AC Caribou	5.17	4.50	2.44	11
	Apica	5.62	5.15	3.53	23
	OAC Minto	5.72	5.19	2.96	17
	94GG	5.05	6.73	2.05	19
	Arrow	5.76	6.02	3.04	20
	8920	6.09	5.12	3.85	12
	Able	5.80	6.45	2.17	16
	Alfa-graze	5.70	5.88	2.61	17
	Spreader3	5.65	4.76	3.03	20
	Prowler1	6.22	5.25	3.32	14
	Mean	*5.68*	*5.50*	*2.90*	*17*
High Residue (10-12cm)	AC Caribou	5.93	5.49	1.93	15
	Apica	6.88	7.15	3.62	19
	OAC Minto	5.80	6.58	2.64	16
	94GG	6.36	6.98	2.89	25
	Arrow	6.55	6.35	3.90	18
	8920	6.32	6.52	3.16	15
	Able	6.29	6.48	3.26	20
	Alfa-graze	6.81	7.39	3.19	21
	Spreader3	5.89	5.14	2.99	24
	Prowler1	6.31	5.82	2.87	16
	Mean	*6.31*	*6.39*	*3.04*	*19*
Hay	AC Caribou	5.31	1.97	2.16	40
	Apica	5.60	2.26	2.65	43
	OAC Minto	4.76	1.49	2.27	49
	94GG	5.08	1.35	2.41	31
	Arrow	4.82	2.49	1.79	42
	8920	5.47	2.30	2.34	40
	Able	5.46	1.70	2.50	40
	Alfa-graze	6.18	1.54	3.26	37
	Spreader3	5.57	2.68	1.35	37
	Prowler1	5.80	2.24	2.54	35
	Mean	*5.41*	*2.00*	*2.33*	*39*
Grand Mean		5.80	4.63	2.76	25
SEM		0.394	1.133	0.63	5.11
F pr. (Method)		0.06	0.02	0.33	0.01
F pr. Method(Past vs Hay)		0.07	0.01	0.16	0.00
F pr. Method(Low vs High)		0.08	0.44	0.76	0.70
F pr. (Cv)		0.05	0.89	0.39	0.38
F pr. (Method.Cv)		0.61	0.93	0.77	0.39
F pr. Method.Cv (Past vs Hay)		0.62	0.60	0.46	0.08
F pr. Method.Cv (Low vs High)		0.49	0.98	0.76	0.95
%CV		12	38	42	32

Table 4. Mean dry matter yield of alfalfa cultivars seeded at the Nappan Research Farm for 1997, 1998 and 1999

Cultivar (Cv)	Alfalfa Dry Matter Yield (t/ha)		
	1997	1998	1999
AC Caribou	0.40	2.66	3.99
Apica	0.53	3.37	4.85
OAC Minto	0.48	2.86	4.42
94GG	0.38	2.06	5.02
Arrow	0.54	3.02	4.95
8920	0.63	2.88	4.65
Able	0.24	2.04	4.88
Alfa-graze	0.59	2.23	4.94
Spreader3	0.40	2.11	4.19
Prowler1	0.53	2.69	4.44
Grand Mean	0.47	2.59	4.63
SEM	0.052	0.769	1.333
F pr. (Cv)	0.00	0.04	0.93
%CV	38	42	39

Farm sites. Three hay replicates were established on farms in the Moncton area of New Brunswick in 1997. Two of the farms under-seeded the alfalfa/timothy mixtures to a cereal crop and the third direct seeded the mixtures. Trials were seeded on June 11 and establishment was fair over all locations. All farm plots were rated for establishment on September 22. On-farm plots were top clipped for weeds on September 1. Farm plots, like those at Nappan, appeared to have recovered from the stress of drought by the fall.

Spring growth for on-farm plots in 1998 was excellent; first harvest was taken on June 5 for all plots seeded in 1997. The data suggest that first production DM yields for 8920, Alfa-graze, Apica, and OAC Minto were all above average; total yields from Able and 94GG were consistently the lowest yielding plots (Table 5). Average plant count was 56 plants/m^2 for farm plots seeded in 1997.

Second production year results on farm indicate an increase in mean seasonal dry matter yield in 1999 of 2.13 t/ha (Table 6) compared to 1.77 t/ha in 1998 (Table 5). Alfalfa production is reduced, 0.27 t/ha in 1999 compared to 0.69 t/ha in 1998. The highest producing alfalfa cultivar was 8920 at 0.61 t/ha. Timothy DM improved to 1.46 t/ha. The amount of weed in the plots remained consistent between growing seasons.

Table 5. Seasonal and botanical dry matter yields with plant counts for 1998, on farm sites seeded in 1997

Cultivar (Cv)	Dry Matter Yield (t/ha)				Plant Count #/m^2
	Seasonal	Alfalfa	Timothy	Other	
AC Caribou	1.77	0.63	0.70	0.45	58
Apica	1.85	0.67	0.85	0.56	42
OAC Minto	1.82	0.69	0.75	0.42	70
94GG	1.58	0.43	0.91	0.24	48
Arrow	1.76	0.85	0.60	0.31	53
8920	1.91	1.01	0.77	0.25	58
Able	1.70	0.78	0.51	0.41	73
Alfa-graze	1.90	0.56	0.99	0.35	29
Prowler1	1.68	0.57	0.71	0.40	72
Grand mean	1.77	0.69	0.75	0.38	56
SEM (Cv)	0.177	0.110	0.205	0.112	9.8
F pr. (Cv)	0.92	0.07	0.80	0.59	0.08
%CV	17	27.6	47	52	31

Table 6. Seasonal and botanical dry matter yields with plant counts for 1999 on farm sites seeded in 1997

Cultivar (Cv)	Dry Matter Yield (t/ha)			
	Seasonal	Alfalfa	Timothy	Other
AC Caribou	2.14	0.32	1.48	0.35
Apica	1.68	0.08	1.36	0.24
OAC Minto	1.99	0.00	1.57	0.43
94GG	2.09	0.29	1.40	0.41
Arrow	2.39	0.54	1.36	0.50
8920	2.64	0.61	1.66	0.36
Able	2.37	0.31	1.75	0.30
Alfa-graze	1.81	0.00	1.40	0.41
Prowler1	2.09	0.30	1.18	0.61
Grand mean	2.13	0.27	1.46	0.40
SEM (Cv)	0.312	0.251	0.218	0.178
F pr. (Cv)	0.55	0.66	0.73	0.91
%CV	21	130	21	63

In 1998 three new sites were seeded on May 13; two of these sites were direct seeded and a third was under-seeded to a cereal crop to be removed as mature grain. Establishment was excellent at all locations. Although there were no marked production differences for total DM, alfalfa DM, or DM produced from other species, there did appear to be differences in the amounts of timothy. Timothy appeared to establish significantly better in plots with Arrow and Alfa-graze. One site had a higher production than the other two; there was enough regrowth for a second hay harvest (July 20 and Sept 30).

The first production season for the 1998 seeding (Table 7) gave a mean DM yield of 3.48 t/ha. When compared with the first production year of the 1997 seeding (Table 5), the mean DM yield of 1.77 t/ha was much lower. This shows how a dry growing season can affect the overall crop yield. The plot yield, and specifically the alfalfa yield, in 1999 is significantly different among the cultivars. AC Caribou is the top producing cultivar at 1.92 t/ha followed by Alfa-graze at 1.20 t/ha. The lowest producing cultivar was 96GG with 0.66 t/ha. It is interesting to note that the cultivars that excelled in the first production year of the 1998 seeding were not those that excelled in the 1997 seeding.

On combining all the hay data from Nappan with two seeding years on farms, we get a clearer picture.

Combined first production year results (Table 8) give a mean seasonal yield of 3.15 t/ha. There is a significant difference in the contribution of the alfalfa cultivars to total DM yield. The three cultivars that contribute the greatest overall yield under hay management were 8920, AC Caribou, and Apica at 1.93, 1.84, and 1.82 t/ha respectfully. The seasonal yield is also specific to individual cultivars. The highest overall producing mixture was Spreader3 at 3.44 t/ha followed by 8920 and Alfa-graze at 3.38 and 3.37 t/ha respectfully. Spreader3 alfalfa had above average yield and was associated with a higher contribution of timothy to total yield.

The second production year's combined results (Table 9) differ from the first production year. The seasonal yield of 4.30 t/ha was greater than 3.15 t/ha in the first production year. There is no significant difference among the cultivars, but Arrow, 8920, Prowler1, and Apica have higher than average yield (Table 9). It is interesting to note the highest seasonal yield in 1999 was the Alfa-graze mixture at 4.72 t/ha. This mixture had a below average contribution to DM by the alfalfa, but the highest contribution by both timothy and other species.

Table 7. Seasonal and botanical dry matter yields with plant counts for 1999, on farm sites seeded in 1998

Cultivar (Cv)	Dry Matter Yield (t/ha)			Plant Count #/m^2
	Seasonal	Alfalfa	Timothy	
AC Caribou	3.84	1.92	1.21	62
Apica	3.49	0.99	1.69	48
OAC Minto	3.27	0.85	1.83	67
94GG	3.29	0.66	1.61	43
Arrow	3.31	0.73	1.60	47
8920	3.72	1.06	1.57	63
Able	3.75	1.11	1.30	43
Alfa-graze	3.62	1.20	1.59	43
Spreader3	3.75	1.04	1.79	53
Prowler1	2.76	0.73	1.12	36
Grand Mean	3.48	1.03	1.53	51
SEM	0.203	0.160	0.233	10.8
F pr.(Cv)	0.04	0.00	0.43	0.51
%CV	10	27	26	37

Table 8. First production year results for 1997 and 1998 seeding under hay management

Cultivar (Cv)		Dry Matter Yield (t/ha)		
	Seasonal	Alfalfa	Timothy	Other
AC Caribou	3.21	1.84	0.69	0.68
Apica	3.19	1.82	0.91	0.51
OAC Minto	3.22	1.60	1.07	0.57
94GG	2.87	0.66	1.07	1.14
Arrow	3.09	1.65	0.92	0.56
8920	3.38	1.93	0.82	0.67
Able	3.09	1.30	0.75	1.04
Alfa-graze	3.37	1.42	1.22	0.74
Spreader3	3.44	1.57	1.20	0.69
Prowler1	2.79	1.36	0.75	0.69
Deep Crown	2.99	1.20	1.01	0.80
Grand mean	3.15	1.49	0.95	0.74
SEM (Cv)	0.140	0.211	0.133	0.131
F pr. (Cv)	0.02	0.00	0.06	0.03
%CV	14	45	44	56

Table 9. Second production year results for 1997 and 1998 seeding under hay management

Cultivar	Dry Matter Yield (t/ha)			
	Seasonal	Alfalfa	Timothy	Other
AC Caribou	4.25	1.42	1.93	0.91
Apica	4.29	1.53	2.22	0.54
OAC Minto	3.84	1.00	2.04	0.81
94GG	4.08	1.00	2.07	1.02
Arrow	4.01	1.84	1.65	0.52
8920	4.53	1.74	2.12	0.67
Able	4.43	1.24	2.25	0.94
Alfa-graze	4.72	1.03	2.64	1.06
Prowler1	4.56	1.59	2.09	0.88
Grand mean	4.30	1.38	2.11	0.82
SEM (Cv)	0.254	0.252	0.327	0.159
F pr. (Cv)	0.28	0.14	0.72	0.18
%CV	16	49	41	52

Conclusions

Alfalfa cultivars selected specifically for grazing were not superior to other cultivars selected for general adaptability. This may indicate that all alfalfa varieties should be evaluated for general adaptability to New Brunswick soil and climatic conditions. In general, cultivars adapted to New Brunswick conditions show superior performance under hay and grazing conditions.

Results at Nappan indicate that over two production years, mixtures containing Apica and Arrow produce more alfalfa, on average, than the others cultivars evaluated in this study, regardless of management regime. Under hay management, Arrow timothy mixtures produced the highest yield of alfalfa during the second production year. The Alfa-graze in mixture produced the highest overall yield, but with one of the lowest contributions of alfalfa and the highest contributions of both timothy and other species. While Alfa-graze has been selected for improved persistence under grazing in the United States, its poor performance in this study suggests that general adaptability is an essential characteristic for utilizing alfalfa under New Brunswick conditions. Publication 100A lists alfalfa cultivars that grow well under our conditions; producers might consider combining these in mixtures. This would ensure that alfalfa populations will continue in the sward throughout the life of forage stands, regardless of management regime.

Alfalfa cultivars in this study had the largest yield potential in mixtures when managed under a high residual grazing regime. However, when alfalfa is the major legume species in a grazing mixture, rotational grazing should be used and livestock should exit the paddocks when the height of the remaining sward is close to 10 cm (lenient grazing pressure). Therefore, if the objective is to maximize forage production, we recommend rotationally-grazed, alfalfa-based forage mixtures.

References

Papadopoulos, Y.A., Price, M.A., Hunter, G.M., McRae, K.B., Laflamme, L.F., Caldwell, C.D. and Fulton, N.R. 1995 Differences among orchardgrass cultivars in response to hay and rotational grazing management. Can. J. Plant Sci. 75:147-157.

Papadopoulos, Y.A., Kunelius, H.T. and Fredeen, A. H. 1993a. Factors affecting pasture productivity in Atlantic Canada. Can. J. Anim. Sci. 73:699-713.

Papadopoulos, Y.A., Simpson, S.E., McKenzie, D., McRae, K.B., Thomas, W.G., Butt, E., Bolton, E., Rodd, A.V. and Martin, R. 1993b. The establishment and persistence of white clover-based pasture mixtures. Final Report. Canada/Nova Scotia Livestock Feed Development Agreement. Agriculture Canada, Experimental Farm, Nappan, N.S.

Rodd, A.V., Wilson R.R., Papadopoulos, Y.A. and Laflamme, L.F. 1992. Effect of cattle trampling on soil properties and pasture production. Final Report. Canada/Nova Scotia Livestock Feed Development Agreement. Agriculture Canada, Experimental Farm, Nappan N.S. 48 pages.

Thomas, W.G. 1990. Pasture mixture study. Pages 23-30 in Field Crops Project results 1990. Nova Scotia Department of Agriculture and Marketing, Truro N.S.

THE EVALUATION OF FORAGE MIXTURES TO IMPROVE LEGUME SPECIES SURVIVAL ON LAND-FORMED DYKELAND

ÉVALUATION DE MÉLANGES FOURRAGERS POUR AMÉLIORER LA SURVIE D'ESPÈCES DE LÉGUMINEUSES DANS LES TERRES MARÉCAGEUSES CULTIVABLES

Y.A. Papadopoulos[1], R.Thériault[2], M.Price[3], K.M.Thomas[4],
S.A.E. Fillmore[5] and/et V.Rodd[6]

Partner / Partenaire: Chignecto Soils and Crops Improvement Association / Association pour l'amélioration des sols et cultures du Chignecto

Abstract: The dale portion of a dykeland flat constitutes 20 to 40% of a dykeland field. Producers are looking for legume mixtures that are successful on dales. This study evaluates legume-based forage mixtures with grasses seeded on dales for productivity and persistence under two management regimes. The trial seeded at the Nappan Research Farm included three different legume mixtures seeded with timothy: red clover, birdsfoot trefoil, and a three legume mixture of alfalfa, birdsfoot trefoil, and red clover. The New Brunswick farm sites were seeded with four mixtures which included: timothy or smooth brome in mixture with birdsfoot trefoil and red clover. On-farm timothy and smooth brome grass were shown in this study to be successful companion grasses on dales. Birdsfoot trefoil and red clover produced well in mixture with grasses on dales while alfalfa did not persist when seeded on dales. The two-cut management system produced more forage and had a higher legume content after two production years than the one-cut management regime.

Résumé : Les basses terres représentent de 20 à 40 % d'un champ marécageux. Les producteurs cherchent à trouver des mélanges de légumineuses qui poussent bien dans les basses terres. La présente étude a pour but d'évaluer des mélanges fourragers à base de légumineuses qui peuvent être ensemencés sur les basses terres avec des graminées, afin d'établir leur productivité et leur longévité dans deux systèmes d'exploitation. Le semis effectué à la ferme expérimentale de Napan comprenait trois différents mélanges de légumineuses ensemencés avec la fléole, le trèfle rouge et le lotier, et un mélange de trois légumineuses ensemencé avec la luzerne, le lotier et le trèfle rouge. Les champs d'essai du Nouveau-Brunswick ont été ensemencés avec quatre mélanges comprenant de la fléole ou du brome inerme dans un mélange avec du lotier et du trèfle rouge. L'essai au champ a révélé que la fléole et le brome inerme sont de bonnes graminées à utiliser dans les basses terres. Le lotier et le trèfle rouge ont donné un bon rendement dans un mélange avec des graminées sur les basses terres, mais la luzerne n'a pas fait preuve de longévité à cet endroit. Par rapport au système

---

[1] Agriculture and Agri-Food Canada, CLRC, Charlottetown, PEI C1A 7M8 / Agriculture et Agroalimentaire Canada, CRCB, Charlottetown, I-P-É C1A 7M8

[2] Department of Agriculture and Rural Development, Moncton, NB E1C 8R3 / Ministère de l'Agriculture et de l'Aménagement rural, Moncton, NB E1C 8R3

[3] Department of Agriculture and Rural Development, Fredericton, NB E3B 5H1 / Ministère de l'Agriculture et de l'Aménagement rural, Fredericton, NB E3B 5H1

[4] Cumberland County Soils and Crops Improvement Association, Nappan, NS B0L 1C0 / Association pour l'amélioration des sols et cultures du comté de Cumberland, Nappan, N.-É. B0L 1C0

[5] Agriculture and Agri-Food Canada, AFHRC, Kentville, NS B4N 1J5 / Agriculture et agroalimentaire Canada, AFHRC, Kentville, N.-É. B4N 1J5

[6] Agriculture and Agri-Food Canada, CLRC, Nappan, NS B0L 1C0 / Agriculture et agroalimentaire Canada, CLRC, Nappan, N.-É B0L 1C0

d'exploitation à une coupe, le système d'exploitation à deux coupes a produit plus de fourrage et présentait une plus grande teneur en légumineuses après deux années de production.

Introduction

Legume-based mixtures are essential for environmentally and economically sound forage production in New Brunswick. Producers have been looking for suitable mixtures to provide adequate forage production on the dales of formed dykeland fields; these dales constitute approximately 20 to 40% of the total field area. Aggressive competition among species in the seeding years may contribute to the difficulty of establishing adapted species. Alfalfa, a high-yielding legume, has been shown to be unsuitable for dale planting (Papadopoulos et al., unpublished data).

This study was designed to evaluate the effect of split seeding (alfalfa-based mixtures on the crown and red clover or trefoil based mixtures on the dales) and selected cutting management (dales harvested once versus twice during the growing season) on productivity and persistence.

Materials and Methods

Nappan Site. A split-plot design with two subdivisions was used in this experiment. The main plot was a split-seeding mixture on each dykeland flat:

Crown (kg/ha)	Dales (kg/ha)
Alfalfa/Timothy (10:5)	Alfalfa/Birdsfoot Trefoil/Red clover/Timothy (3:3:3:5)
Alfalfa/Timothy (10:5)	Timothy/Red Clover (7:5)
Alfalfa/Timothy (10:5)	Timothy/Birdsfoot Trefoil (8:4)

The sub-plot treatments are one of the two dales harvested once and the other harvested twice. A randomized technique was used to ensure that each sub-treatment was assigned to the two differing sides of the form (north and south). Treatments were replicated three times for a total of nine formed dykeland flats.

Crowns and dales were seeded to the above mixtures on June 4, 1997 at the Nappan Research Farm. Plots were fertilized with 450 kg/ha of 5-10-30+2B prior to seeding. On May 1, 1998 fertilizer 5-20-20 was applied at a rate of 400 kg/ha. Flats were harvested on June 22, and first-cut dry matter yield and botanical composition were determined. A second dry matter yield was determined on August 5, 1998. The number of legume plants/m^2 for each species was recorded on July 9 following first harvest. In the second production year, first cut and second cut were on June 14 and July 22, 1999 respectively. The plant count was recorded on July 9, 1999 following first harvest. Dry matter yield and stand count were determined from three 0.25m^2 quadrant samples taken from each dale and crown for a total of nine samples per flat. Botanical composition was determined from a combined sample of five 400cm^2 quadrants taken along each dale or crown for each harvest in 1999.

Farm Sites. A randomized complete block design with three replications was used in this experiment; each farm site was considered as one replication. Plots were seeded to mixtures as follows:

Crown (kg/ha)	Dales (kg/ha)
Timothy/Alfalfa (10:5)	Timothy/Red Clover (7:5)
Timothy/Alfalfa(10:5)	Timothy/Red Clover (7:5)
Timothy/Alfalfa(10:5)	Timothy/Birdsfoot Trefoil (8:4)
Meadow Brome/Alfalfa (10:10)	Meadow Brome/Red Clover (10:8)
Smooth Brome/Alfalfa (10:10)	Smooth Brome/Birdsfoot Trefoil (10:8)

This experiment was seeded on the land-formed dykeland fields of two farms (Richard Brooks and John Carlisle) in the Sackville, New Brunswick area on July 15 and 16, 1997, and on a third farm (George Trueman) on August 27, 1998. Fertilizer was applied at seeding (450 kg/ha of 5-10-30+2B). In the first production year, plots for the 1997 seedings were harvested on June 4, 1998 for the Carlisle farm and June 4, July 14, and August 29, 1998 for the Brooks farm. For the 1998 seeding, the Trueman site was harvested June 7 and August 16, 1999. In the second production year, the Carlisle site was harvested July 12 and September 9, 1999 and the Brooks site was harvested on June 7 and July 26, 1999. Plant counts and botanical separations were taken after the first harvest for all sites in both production years. Dry matter yield and stand count were determined from three 0.25m^2 quadrant samples taken from each dale and crown for a total of nine samples per flat. Botanical composition was determined from a combined sample of five 400cm^2 quadrants taken along each dale or crown for each harvest in 1999.

Results and Discussion

At the Nappan site, the first year's mean seasonal yield of dales (Table 1) was greater than that of the second year (Table 2): 3.09 t/ha versus 2.12 t/ha. There was a large reduction in red clover plants between 1998 (Table 3) and 1999 (Table 4). Red clover numbers were slightly reduced, from 12 to 7 plants/m^2. After visually inspecting the red clover plants, we found that many of the tap roots had been completely damaged by soil organisms. Warmer than average winter conditions may have resulted in soil environments that promoted root rot organisms; this may explain the decline in red clover population.

Alfalfa, on average, was reduced from 18 to 2 plants/m^2. Previous work indicates that high water tables in the fall and/or following spring are responsible for declining alfalfa populations on the dales of the dykelands.

Table 1. First production year results on dales at Nappan Research Farm in 1998

Method	Legume mixture (Dales)	Dry matter yield (t/ha)							
		Cut 1	Cut 2	Total	Alfalfa	Red Clover	Trefoil	Timothy	Other
1 Cut	Red Clover	2.75	-	2.75	-	1.63	-	0.98	0.14
	B Trefoil	2.82	-	2.82	-	-	0.88	1.36	0.46
	Af,Rc,Bt	2.79	-	2.79	0.09	0.18	0.23	1.83	0.46
	Mean	*2.79*	-	*2.79*	*0.09*	*0.91*	*0.56*	*1.39*	*0.36*
2 Cut	Red Clover	2.41	0.52	3.45	-	0.68	-	2.14	0.63
	B Trefoil	2.75	-	2.75	-	-	0.53	1.53	0.69
	Af,Rc,Bt	2.73	0.63	3.99	0.06	0.02	0.28	3.12	0.50
	Mean	*2.63*	*0.57*	*3.40*	*0.06*	*0.35*	*0.40*	*2.26*	*0.61*
Means (Mixture)	Red Clover	2.58	0.52	3.10	-	1.16	-	1.56	0.39
	B Trefoil	2.79	-	2.79	-	-	0.71	1.45	0.58
	Af,Rc,Bt	2.76	0.63	3.39	0.08	0.10	0.25	2.48	0.48
Grand Mean		2.71	0.57	3.09	0.08	0.63	0.48	1.83	0.48
SEM		0.247	0.087	0.292	0.029	0.143	0.265	0.254	0.209
F.pr. (mixture)		0.615	0.457	0.200	-	0.011	0.123	0.005	0.780
F.pr. (method)		0.509	-	0.055	0.607	0.031	0.668	0.016	0.063
F.pr. (mixture.method)		0.858	-	0.208	-	0.080	0.584	0.246	0.322
%CV		17.6	147.9	17.5	65.8	46.6	119.7	30.7	48.7

Table 2. Second production year results on dales at Nappan Research Farm in 1999

Method	Legume mixture (Dales)	Dry matter yield (t/ha)							
		Cut 1	Cut 2	Total	Alfalfa	Red Clover	Trefoil	Timothy	Other
1 Cut	Red Clover	1.67	-	1.67	-	0.13	-	1.07	0.47
	B Trefoil	2.00	-	2.00	-	-	0.07	1.24	0.69
	Af,Rc,Bt	1.68	-	1.68	0	0.19	0.02	1.01	0.45
	Mean	*1.78*	-	*1.78*	0	*0.16*	*0.04*	*1.11*	*0.54*
2 Cut	Red Clover	1.82	0.48	2.30	-	0.61	-	1.09	0.61
	B Trefoil	1.88	0.63	2.51	-	-	0.33	1.12	1.06
	Af,Rc,Bt	1.86	0.72	2.57	0.20	0.25	0.16	1.00	0.97
	Mean	*1.85*	*0.61*	*2.46*	*0.20*	*0.43*	*0.25*	*1.07*	*0.88*
Means (Mixture)	Red Clover	1.75	0.48	1.99	-	0.37	-	1.08	0.54
	B Trefoil	1.94	0.63	2.26	-	-	0.20	1.18	0.87
	Af,Rc,Bt	1.77	0.72	2.13	0.10	0.22	0.09	1.00	0.71
Grand Mean		1.82	0.61	2.12	0.10	0.30	0.15	1.09	0.71
SEM		0.136	0.189	0.142	0.095	0.212	0.093	0.130	0.208
F.pr. (mixture)		0.423	0.690	0.173	-	0.542	0.257	0.424	0.138
F.pr. (method)		0.513	-	0.002	0.281	0.288	0.136	0.732	0.166
F.pr. (mixture.method)		0.472	-	0.529	-	0.393	0.613	0.883	0.783
%CV		11.9	53.6	13.5	167.2	127.7	131.1	21.9	64.7

Table 3. Alfalfa, Red Clover and Trefoil Plant Counts Plants m^2 at Nappan 1998

Method	Legume mixture (Dales)	Alfalfa Plant Count # m^{-2}	R. Clover Plant Count # m^{-2}	Trefoil Plant Count # m^{-2}
1 Cut	Red Clover	-	11	-
	B Trefoil	-	-	21
	Af,Rc,Bt	24	7	8
	Mean	*24*	*9*	*14*
2 Cut	Red Clover	-	23	-
	B Trefoil	-	-	17
	Af,Rc,Bt	12	7	3
	Mean	*12*	*15*	*10*
Means (Mixture)	Red Clover	-	17	-
	B Trefoil	-	-	19
	Af,Rc,Bt	18	7	6
Grand Mean		18	12	12
SEM		11	5.6	4
F.pr. (mixture)		-	0.075	0.114
F.pr. (method)		0.482	0.115	0.308
F.pr.(mix. method)		-	0.115	0.838
%CV		101.2	47.2	51.6

Birdsfoot trefoil numbers stayed the same from year to year. Both red clover and birdsfoot trefoil had greater plant numbers on the dales that were harvested twice during the season, as compared to alfalfa which was more productive on the one-cut dales.

In 1998, the best producing mixture was the triple legume mixture seeded with timothy at 3.39 t/ha, followed by red clover and trefoil at 3.10 and 2.79 t/ha respectively. There was a significant difference in total seasonal yield between harvest methods (one versus two harvests) over the two seasons. In 1998, red clover and timothy were both affected by seeding mixture and harvesting method (Table 1). In the first production year, red clover was the most successful when seeded with just timothy, and contributed most to overall yield in the one-cut system. Conversely, timothy was most successful as a companion for the three legume mixture and had the most production in the two-cut system. Although birdsfoot trefoil did not contribute as much dry matter as red clover in the single mixture, it did contribute the most in the triple legume mixture. Alfalfa had sufficient plant numbers in 1998, but its production on dales was low (0.08t/ha).

In the second production year, the yield of all legumes species was reduced (Table 2). The birdsfoot trefoil mixture had the highest yield in 1999. Alfalfa production continued to decline with virtually no growth on the one-cut dales and an increase

Table 4. Alfalfa, Red Clover and Trefoil Plant Counts Plants m^2 at Nappan 1999

Method	Legume mixture (Dales)	Alfalfa Plant Count # m^{-2}	R. Clover Plant Count # m^{-2}	Trefoil Plant Count # m^{-2}
1 Cut	Red Clover	-	10	-
	B Trefoil	-	-	8
	Af,Rc,Bt	3	4	11
	Mean	*3*	*7*	*9*
2 Cut	Red Clover	-	10	-
	B Trefoil	-	-	16
	Af,Rc,Bt	1	5	10
	Mean	*1*	*8*	*13*
Means (Mixture)	Red Clover	-	10	-
	B Trefoil	-	-	12
	Af,Rc,Bt	2	8	10
Grand Mean		2	7	11
SEM		1.3	2.5	6.8
F.pr. (mixture)		-	0.010	0.742
F.pr. (method)		0.423	0.808	0.659
F.pr.(mix. method)		-	0.808	0.588
%CV		122.5	81.0	122.6

from 1998 in growth on the two-cut dales. Red clover produced a greater yield under the two-cut harvests as compared with the first production year.

On farms, the overall seasonal yield was greater in 1999 at 5.21 t/ha (Table5) than in 1998 at 3.89 t/ha (Table 6). There were no significant differences among the on-farm seeded mixtures for both 1998 and 1999. During the first production year, the second cut yield was greater than the first cut yield. The best producing mixtures on dales in the first production year was the timothy/red clover and smooth brome/red clover at 4.16 and 4.13 t/ha respectively. All mixtures seeded on dales had excellent yield in 1999. In the second production year, the smooth brome/red clover mixture had the highest yield at 5.56 t/ha.

On-farm plant counts indicate a decrease in legume plant density from a mean of 60 plants/m^2 in 1998 (Table 5) to 19 plants/m^2 in 1999, (Table 6) This coincides with a reduction of individual legume species in 1999 (Table 8). Red clover production in 1999 was only 1/3 of that of 1998 (Table 7). Birdsfoot trefoil was reduced from 0.86 to 0.49 t/ha. The smooth brome grass content also decreases slightly in 1999, while the content of timothy on farms doubled to 2.12 t/ha in 1999. The reduction in legume species was correlated with an increase in weeds on farm plots.

Table 5. First production year dry matter yield on dales for on-farm trials 1998

Seeded mixtures (crown;dale)	Dry Matter Yield (t/ha)			Legume Plant Count #/m^2
	Cut 1	Cut 2	Seasonal	
Tm/Af;Tm/Rc	1.81	2.35	4.16	80
Tm/Af;Tm/Bt	1.51	2.19	3.70	42
SB/Af;SB/RC	1.90	2.23	4.13	76
SB/Af;SB/Bt	1.61	1.70	3.31	24
Grand mean	1.72	2.12	3.89	60
SEM	0.104	-	0.209	-
F. pr.	0.057	-	0.101	-
%CV	8.5	-	7.6	-

Table 6. Second production year dry matter yield on dales for on-farm trials 1999

Seeded mixtures (crown;dale)	Dry Matter Yield (t/ha)			Legume Plant Count #/m^2
	Cut 1	Cut 2	Seasonal	
Tm/Af;Tm/Rc	2.63	2.53	5.15	21
Tm/Af;Tm/Bt	2.68	2.37	5.05	27
SB/Af;SB/RC	2.77	2.79	5.56	13
SB/Af;SB/Bt	2.66	2.46	5.12	16
Grand mean	2.67	2.53	5.21	19
SEM	0.257	0.274	0.466	-
F. pr.	0.943	0.848	0.902	-
%CV	16.7	18.7	15.5	-

Table 7. Dale botanical component dry matter yield on-farm trials 1998

Seeded mixtures (crown;dale)	Dry Matter Yield (t/ha)				
	Timothy	Brome	Red Clover	Trefoil	Other
Tm/Af;Tm/Rc	0.68	-	1.26	-	0.15
Tm/Af;Tm/Bt	1.25	-	-	1.33	0.55
SB/Af;SB/RC	-	1.38	2.18	-	0.31
SB/Af;SB/Bt	-	1.72	-	0.38	0.10
Grand mean	0.87	1.55	1.57	0.86	0.25
SEM	0.345	0.399	0.400	0.66	0.717
F. pr.	0.516	0.652	0.412	0.493	0.580
%CV	44.9	36.3	127.0	109.0	68.4

Table 8. Dale botanical component DM yield on-farm trials 199 9

Seeded mixtures (crown;dale)	Dry Matter Yield (t/ha)				
	Timothy	Brome	Red Clover	Trefoil	Other
Tm/Af;Tm/Rc	2.06	-	0.41	-	1.17
Tm/Af;Tm/Bt	2.18	-	-	0.75	0.65
SB/Af;SB/RC	-	1.51	0.69	-	1.37
SB/Af;SB/Bt	-	1.31	-	0.23	1.80
Grand mean	2.10	1.41	0.51	0.49	1.23
SEM	0.088	0.247	0.054	0.166	0.252
F. pr.	0.501	0.667	0.206	0.160	0.262
%CV	19.2	30.3	7.5	58.7	32.7

Conclusions

In this study, alfalfa did not prove suitable to be included in mixtures for seeding on dykeland dales. In comparison, both smooth brome grass and timothy were productive companion grasses when seeded on dales. The on-farm trials indicate that both red clover and birdsfoot trefoil produced well in mixtures on dales. Overall, legume production was more successful under the two-cut harvesting regime. This study indicates that producers can choose to combine red clover or birdsfoot trefoil with either timothy or brome grass for seeding the dales of formed dykeland fields.

EVALUATION OF VARIOUS HERBICIDES ON AUBADE AND BARSPECTRA RYEGRASS GROWN FOR SEED

RAYGRASS BARSPECTRA CULTIVÉ POUR LA SEMENCE

K.V. McCully[1], J.A. Ivany[2], M. Melanson[1], M. Price[3] and/et A. Smith[3]

Partner/Partenaire: New Brunswick Soil & Crop Improvement Association / L'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick

Abstract : A trial to evaluate various herbicide treatments on crop tolerance and weed control was conducted on both Aubade and Barspectra ryegrass varieties in Hartland, New Brunswick. Visual evaluations on crop tolerance and weed control were collected throughout the season. In addition, yields, thousand kernel weights, and percent germination data were also collected. Results indicated that the only treatments to cause crop injury levels greater than 10% anytime throughout the season, on both Barspectra and Aubade varieties, were Refine Extra + Agral 90 applied at 20 g/ha + 0.2% v/v, and 40 g/ha + 0.2% v/v. Injury levels were as high as 21% and 25% from Refine Extra + Agral 90 (20 g/ha + 0.2% v/v) on Barspectra and Aubade varieties respectively (10 days after treatment), and 34% to 36% from Refine Extra + Agral 90 (40 g/ha + 0.2% v/v) on Barspectra and Aubade varieties respectively (10 days after treatment) . Injury was in the form of crop stunting with a slight off colour. Injury lasted approximately 6 to 7 weeks. By the final rating, no significant crop injury was observed from any of the treatments.. Yield and percentage germination data also indicated that differences amongst treatments were not significant on either Aubade or Barspectra ryegrass varieties. Thousand kernel weights from treatments applied to Barspectra were not significantly different from each other, but were on Aubade. Only MCPA Na 300, Buctril M (2 L/ha), and Dyvel had thousand kernel weights not significantly lower than the untreated control on Aubade ryegrass. All treatments provided excellent lamb's quarters control (99-100%) by the final rating (July 22). Results from these trials indicated that any of the tested herbicides and rates could be used safely and effectively on both Barspectra and Aubade ryegrass varieties. Further testing with Refine Extra + Agral 90 may be warranted to verify tolerance however.

Résumé : Un essai réalisé à Hartland (N.-B.) a permis d'évaluer la tolérance des variétés de ray-grass Aubade et Barspectra à divers traitements herbicides et l'efficacité des traitements contre les mauvaises herbes. Des évaluations visuelles de la tolérance des cultures et de la destruction des mauvaises herbes ont été faites tout au long de la saison. On a aussi recueilli des données sur les rendements, sur le poids de mille grains et sur le taux de germination. Les résultats indiquent que les seuls traitements qui ont endommagé plus de 10 % des plants des variétés Barspectra et Aubade pendant la saison étaient le Refine Extra + Agral 90 appliqué à raison de 20 g/ha + 0,2 % v/v et de 40 g/ha + 0,2 % v/v. Dix jours après l'application, le Refine Extra + Agral 90, à la dose de 20 g/ha + 0,2 % v/v, avait endommagé 21 % des plants de la variété Barspectra et 25 % des plants de la variété Aubade, et le Refine Extra + Agral 90, à la dose de 40 g/ha + 0.2% v/v, avait endommagé 34 % et 36 % des plants des variétés Barspectra et Aubade respectivement. Les plants altérés étaient rabougris et un peu décolorés. Ces symptômes ont duré 6 à 7 semaines. Au dernier examen, aucune altération importante n'était visible sur les plants quel que soit le traitement. Les données sur le rendement et le taux de germination ont aussi indiqué que les écarts entre les traitements n'étaient pas très grands pour les deux variétés Aubade et Barspectra. Le poids de mille grains de la variété Barspectra variait peu entre les traitements, mais on a relevé des écarts notables pour la variété Aubade. Le poids de mille grains de ray-grass Aubade était un peu inférieur sur les parcelles traitées avec les produits MCPA Na 300, Buctril M (2 L/ha) et Dyvel que sur la parcelle témoin non traitée. Tous les traitements ont donné d'excellents résultats contre le chénopode (99 à 100 %) selon l'évaluation finale (22 juillet). En général, les résultats de ces essais indiquent que tous les herbicides testés, peu importe la dose, peuvent être utilisés efficacement et sans risque sur les variétés de ray-grass Barspectra et Aubade. D'autres essais doivent cependant être faits pour vérifier leur tolérance au Refine Extra + Agral 90.

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1/ Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

[2] Agriculture and Agri-Food Canada - Crops and Livestock Research Centre, Charlottetown, PEI C1A 7M8 / Agriculture et Agroalimentaire Canada - Centre de recherches sur les cultures et les bestiaux, Charlottetown, I-P-É C1A 7M8

[3] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB E3B 5H1 / Élevage et alimentation des animaux, MAARNB, Fredericton, NB E3B 5H1

Introduction

Interest in growing ryegrass for seed production in the Maritime region has been on the increase the past few years. It is felt that good market opportunities exist for this crop, and would fit well into most cropping rotations.

One of the limitations of growing ryegrass for seed however, is the lack of herbicides available for weed control. If this crop is to be grown successfully, weeds must be controlled in order to prevent unwanted competition and to prevent weed seed contamination at harvest. Herbicides will therefore be an important part of a weed management program for ryegrass grown for seed.

In order to evaluate herbicides which would result in the least amount of crop injury and provide the greatest level of weed control, a trial was established on both Aubade and Barspectra ryegrass varieties.

Materials and Methods

Barspectra and Aubade ryegrass varieties were seeded in Hartland, Carleton County on May 5th, 1999 at a rate of 18.4 kg/ha and 29.5 kg/ha respectively. An application of 34-0-0 fertilizer at a rate of 150 kg/ha was applied on May 13. Ryegrass was seeded using a Wintersteigner Oyjord plot seeder. The soil was a loam with a sand/silt/clay ratio of 31/49/20. The organic matter content was 3.4% and the soil pH was 6. The trials consisted of 8 treatments for each variety, and were replicated 5 times. The treatments included an untreated control, a 1X and 2X Refine Extra + Agral 90 rate, MCPA NA 300, Dyvel, Basagran Forte + extra surfactant (Assist) , and Buctril M applied at a 1X and 2X rate. Experimental design was a randomized complete block. Plot size was 1.5 m x 7.5 m.

The herbicides were applied using a CO_2 handheld sprayer delivering a water volume of 200 L/ha at a pressure of 207 KPa. Treatments were applied June 4 when the majority of ryegrass was at the 4 leaf stage (range 3 to 6 leaves) and between 10 to 12 cm in height. The two major weeds present at the time of spraying were lamb's quarter and wild buckwheat. At application the majority of lamb's quarters plants were approximately 10 cm high and at the 6 leaf stage.

Crop injury and weed control ratings were taken on June 14, June 24, July 15, and July 22. Ratings were taken on a scale of 0-100, where 0 represented no control or injury, and 100 represented a complete kill. Aubade ryegrass was harvested on July 28, and Barspectra ryegrass on August 4. Harvest was done with a sickle bar mower over a 1 x 7m area from each plot. Seed was put into burlap bags and hung in an open barn to dry. Seeds were later threshed with an Hege 140 plot combine, cleaned, and weighed. Data on thousand kernel weights and seed germination were also collected. Germination tests were performed over 7 days for Barspectra, and 9 days for Aubade. Germination tests were done at room temperature, by placing 10 seeds from each treatment on wet filter paper in petri dishes.

Data was subjected to an analysis of variance, and means separated by the Least Significant Difference Test (LSD) when the F test was significant at the 5% level. Bartlett's test was used to determine homogeneity of variance, and data was arcsin transformed where required.

Results and Discussion

Aubade Ryegrass Injury. The only treatments causing crop injury greater than 10% by June 14 (10 days after treatment - DAT) resulted from Refine Extra + Agral 90 applied at 20 g/ha + 0.2% v/v (25%) and 40 g/ha + 0.2% v/v (36%) (see Table 1). Injury was in the form of stunting and a slight off color. Buctril M applied at 2 L/ha (9%) and 1 L/ha (6%) caused the next highest levels of injury, but was not considered detrimental. The remaining treatments of Basagran Forte + Assist (4.0%), Dyvel (1%), and MCPA NA 300 (1%) all caused minor injury and were not significantly different from the untreated control (Table 1).

By June 24 (20 DAT), the only treatments displaying injury symptoms significantly higher than the untreated control were the same two treatments of Refine Extra + Agral 90 applied at 20 g/ha + 0.2% v/v (6.0%) and 40 g/ha + 0.2% v/v (13%) (Table 1). As the season progressed these injury symptoms became less evident. By the final July 22 rating (48 DAT) all visible injury symptoms had disappeared. At this time no injury was observed from any of the treatments (Table 1).

Barspectra Ryegrass Injury. Crop injury results on Barspectra ryegrass was very similar to that observed on Aubade ryegrass. The only treatments causing crop injury greater than 8% by June 14 (10 days after treatment - DAT) resulted from Refine Extra + Agral 90 applied at 20 g/ha + 0.2% v/v (21%), and 40 g/ha + 0.2% v/v (34%) (Table 2). Injury was in the form of stunting and a slight off color. Basagran Forte + Assist (8%), and Buctril M applied at 2 L/ha (7%) caused the next highest level of crop injury, but was not considered detrimental. The remaining treatments of Buctril M - 1 L/ha (6%), MCPA Na 300 (3%), and Dyvel (0%) all caused injury levels not significantly different from the untreated control (Table 2).

By June 24 (20 DAT), the only treatments displaying injury symptoms significantly higher than the untreated control were the same two treatments of Refine Extra + Agral 90 applied at 20 g/ha + 0.2% v/v (12%), and 40 g/ha + 0.2% v/v (27%) (Table 2). As the season progressed these injury symptoms became less evident. By the final July 22 rating (48 DAT), no significant differences existed between any of the treatments and the untreated control (Table 2).

Table 1. Crop injury, weed control, yields, % of germination and thousand kernel weight for Aubade ryegrass

Treatments	Product Rate	Crop injury (0-100%)			Lambs quarters control (0-100%)		Yields (kg/ha)	TKW[1] (g)	germination at 9 days (%)
		June 14	June 24	July 22	June 14	July 22	July 28		
Untreated	-	0 e*	0c	0	0f	0c	1198	3.92a	96
Refine Extra + Agral 90	20 g/ha + 0.2% v/v	25.0b	6.0b	0	75d	99ab	1050	3.57bc	86
Refine Extra + Agral 90	40g /ha + 0.2% v/v	36.0a	13.0a	0	75d	100a	1113	3.45c	92
MCPA Na 300	2.8 L/ha	1.0e	0c	0	50e	100a	1203	3.90a	92
Dyvel	1.25 L/ha	1.0e	0c	0	50e	100a	1140	3.77ab	90
Basagran Forte + Assist	2.08 L/ha	4.0de	1.0c	0	82c	97b	1247	3.63bc	92
Buctril M	1.0 L/ha	6.0cd	2.0c	0	95b	100a	1197	3.61bc	84
Buctril M	2.0 L/ha	9.0c	0c	0	98a	100a	1134	3.78ab	88
LSD[2]		3.7	3.3	N.S.	4.9	2.3	N.S.	0.26	N.S.

* means followed by the same letter within a column are not significantly different from each other (LSD)

[1] Thousand Kernel Weights.

[2] Least Significant Difference

Table 2. Crop injury, weed control, yields, % of germination and thousand kernel weight for Barspectra ryegrass

Treatments	Product Rate	Crop injury (0-100%)			Lambs quarters control (0-100%)		Yields (kg/ha)	TKW[1] (g)	germination at 7 days (%)
		June 14	June 24	July 22	June 14	July 22	August 4		
Untreated	-	1.0de	0c	0	0e	0b	463	3.11	87
Refine Extra + Agral 90	20 g/ha + 0.2% v/v	21.0 b	12.0b	0	73.0c	100a	530	2.91	92
Refine Extra + Agral 90	40g /ha + 0.2% v/v	34.0a	27.0a	1.0	74.0c	100a	433	2.79	88
MCPA Na 300	2.8 L/ha	3.0de	0c	0	50.0d	99.0a	521	3.12	90
Dyvel	1.25 L/ha	0e	0c	0	50.0d	100a	543	3.22	85
Basagran Forte + Assist	2.08 L/ha	8.0c	0c	0	84.0b	99a	565	3.05	93
Buctril M	1.0 L/ha	6.0cde	0c	2.0	89.0b	100a	504	2.96	87
Buctril M	2.0 L/ha	7.0cd	1.0c	0	99.0a	100a	474	2.95	90
LSD[2]		6.1	5.3	N.S.	6.8	1.5	N.S.	N.S.	N.S.

* means followed by the same letter within a column are not significantly different from each other (LSD 5%)

[1] Thousand Kernel Weights

[2] Least Significant Difference

At this time none of the treatments displayed injury symptoms greater than 2% (Table 2).

Yields. Although yields varied from treatment to treatment on both Aubade and Barspectra ryegrass, differences between treatments and the untreated control were not statistically significant.

Aubade untreated control yields were 1198 kg/ha while the herbicide treated plots yields ranged from a low of 1050 kg/ha (Refine Extra 20 g/ha + 0.2% v/v) to a high of 1247 kg/ha (Basagran Forte + Assist) (Table 1). Barspectra untreated control plots yielded 463 kg/ha while the herbicide treated plots ranged from a low of 433 kg/ha (Refine Extra + Agral 90) to a high of 565 kg/ha (Basagran Forte + Assist) (Table 2). Basagran Forte + Assist had the highest yields on both Aubade (1247 kg/ha) and Barspectra (565 kg/ha) ryegrass (Table 1 and 2).

Overall, Barspectra yields were considerably lower than Aubade. This was expected however, as Aubade is known to be a higher yielder.

Thousand Kernel Weights. To help determine if a relationship between seed size and yields existed, thousand kernel weights were collected for each treatment on each variety. Thousand kernel weight analysis indicated that differences between individual treatments and the untreated control were not considered significant for Barspectra ryegrass. Differences in thousand kernel weights between treatments for Aubade was considered significant, however. The untreated control had the highest Aubade thousand kernel weights and the only treatments with thousand kernel weights not significantly less were MCPA Na 300, Buctril M at 2 L/ha, and Dyvel (Table 1). The two Refine Extra + Agral 90 treatments resulted in the lowest thousand kernel weights on Aubade, as well as on Barspectra.

Reasons for differences in thousand kernel weights between the same treatments when applied to Aubade and Barspectra ryegrass is not fully understood.

Percent Germination Tests. In order to determine if the tested herbicides influenced germination of harvested ryegrass seed, a germination test was performed for each treatment on both Aubade and Barspectra ryegrass varieties.

Percent germination on Aubade ryegrass from the herbicide treated plots, ranged from 84% to 92%, but was not considered significantly different from each other or the untreated control (96%)(Table 2). Percent germination on Barspectra ryegrass from the herbicide treated plots, ranged from 85 to 93%, and also was not significantly different from each other or the untreated control (87%). Percent germination was therefore not significantly influenced by herbicide application to either variety.

Weed Control. Weed pressure was not considered high in the trial area. The most predominant weed observed was lamb's quarters, followed by wild buckwheat. Only lamb's quarters data will be reported however, as wild buckwheat distribution and densities were not consistent.

1. Lamb's quarters. Lamb's quarters control ratings from the various treatments were similar on both Aubade and Barspectra ryegrass varieties.

Ratings collected on June 14 (10 days after treatment -DAT) indicated that all treatments provided significantly higher lamb's quarters control than the untreated control within each variety (Table 1 and 2). The speed of die down did however vary between treatments at this time. The fastest lamb's quarters burndown within each variety resulted from Buctril M. On Barspectra ryegrass, Buctril M applied at 2 L/ha resulted in 99% lamb's quarters control, and on Aubade ryegrass 98% control (10 DAT)(Tables 1 and 2). On Barspectra ryegrass Buctril M applied at 1 L/ha resulted in 89% control of lamb's quarters and on Aubade ryegrass 95% control (10 DAT)(Tables 1 and 2).

The next fastest lamb's quarters burndown recorded (10 DAT) within each variety resulted from Basagran Forte + Assist - 84% and 82% control within Barspectra and Aubade varieties respectively (Tables 1 and 2). Refine Extra + Agral 90 at 40 g/ha + 0.2% v/v resulted in 74% and 75% lamb's quarters control in Barspectra and Aubade respectively. Refine Extra + Agral 90 (20 g/ha + 0.2% v/v) provided similar results with 73% and 75% control within Barspectra and Aubade respectively (Tables 1 and 2). Rate did not influence the level of lamb's quarters control with Refine Extra.

The two treatments providing the slowest burndown resulted from MCPA Na, and Dyvel. These treatments both resulted in 50% lamb's quarters control within both Barspectra and Aubade varieties (10 DAT).

By July 22 (48 DAT) all herbicide treatments provided at least 97% control of lamb's quarters within both Aubade and Barspectra ryegrass varieties. All herbicides evaluated therefore provided excellent lamb's quarters control by the end of the season, regardless of the ryegrass variety the herbicides were applied to.

Conclusions

The only treatments to result in greater than 10% crop injury on either Aubade or Barspectra ryegrass varieties, at anytime throughout the rating period, were Refine Extra + Agral 90 applied at 20 g/ha + 0.2% v/v, and 40 g/ha + 0.2% v/v. Injury from Refine Extra + Agral 90 (20 g/ha + 0.2% v/v) was as high as 25% on Aubade, and 21% on Barspectra ryegrass. Injury from Refine Extra + Agral 90 (40 g/ha + 0.2% v/v) was as high as 36% on Aubade, and 34% on Barspectra ryegrass. Injury was in the form of crop stunting, but was relatively short-lived as either no injury or only minor injury (<5%) was observed 6-7 weeks after application. All the remaining treatments had less than 9% injury within 10 days of application, and less than 2% within 20 days of application. Visually, there did not appear to be a difference in varietal response to the herbicides evaluated.

Although Aubade and Barspectra yields varied from treatment to treatment and the untreated control, statistical analysis indicated that differences were not considered significant. Basagran Forte + Assist treated plots resulted in the highest yields on both Aubade and Barspectra ryegrass varieties, however.

Thousand kernel weight analysis indicated that differences between individual treatments and the untreated control were not considered significant for Barspectra. Differences in thousand kernel weights between treatments for Aubade was considered significant however. The untreated control had the highest Aubade thousand kernel weights and the only treatments which had thousand kernel weights not significantly less were MCPA Na 300, Buctril M at 2 L/ha, and Dyvel (Table 1). The two Refine Extra + Agral 90 treatments resulted in the lowest thousand kernel weights on Aubade, as well as on Barspectra.

Percent germination analysis from all the tested treatments on each variety, indicated that differences were not significant. Germination was therefore not significantly affected by the herbicide treatments on either Aubade or Barspectra ryegrass.

Lamb's quarters was the predominant weed found in the trial area. Although differences in the speed of kill existed between treatments, by the final rating (July 22) all the herbicide treatments provided excellent lamb's quarters control (99-100%).

Overall, based on final % crop injury ratings, yields, % germination, and % lamb's quarters control, it appears that any of the tested herbicides and rates could be used safely and effectively on both Aubade and Barspectra ryegrass varieties. Further testing with Refine Extra + Agral 90, particularly at the 2x rate maybe warranted however to verify crop safety.

Acknowledgements

Special thanks are extended to Anthony Smith (NBDARD) and his summer crew for their assistance with the planting and harvesting of the ryegrass. Special thanks to AAFC Charlottetown for providing the seed for the trial.

PEST MANAGEMENT / LUTTE ANTI-PARASITAIRE

CONTROL OF LEAF SPOT AND POWDERY MILDEW IN WILD BLUEBERRY

CONTRÔLE DE LA TACHE DES FEUILLES ET DU BLANC DU BLEUET SAUVAGE

K. Lynch[1] and/et Michel Melanson[1]

Abstract: Control of leaf spot and powdery mildew was evaluated at two sites in Central and Northeastern New Brunswick. Fungicides evaluated were; propiconazole (Topas 250E 500ml/ha), myclobutanil (Nova 40W 340g/ha), flusilazol (Nustar 20DF 200g/ha), cyprodinil (Vangard 75 WG 740g/ha) and fenbuconazole (Indar 75 WP 140g/ha). Applications were made on 16, 28 June, 9 July (Trial 1) and 18, 30 June, 13 July (Trial 2). Disease incidence at both locations was trace to low and no significant differences were found between the treatments and the control.

Résumé : On a procédé à une évaluation de la lutte contre la tache des feuilles et le blanc dans deux emplacements du Centre et du Nord-Est du Nouveau-Brunswick. Les fongicides alors étudiés était le propiconazole (Topas 250E 500 ml/ha), le myclobutanil (Nova 40W 340 g/ha), le flusilazol (Nustar 20DF 200 g/ha), le cyprodinil (Vangard 75 WG 740 g/ha) and le fenbuconazole (Indar 75 WP 140 g/ha). Les applications ont été faites les 16 et 28 juin et le 9 juillet (premier essai) et les 18 et 30 juin et le 13 juillet (deuxième essai). On a remarqué une faible incidence des maladies aux deux endroits et aucune différence importante n'a été notée entre les superficies traitées et les superficies de contrôle.

Introduction

Leaf spots and powdery mildew are major diseases of wild blueberries in New Brunswick. High incidence of these diseases in late July and August can cause premature defoliation, reduced fruit size and lower yields. New information on the control of leaf diseases in wild blueberry is limited. The University of Maine conducted extensive field trials however in the 1930s. These trials evaluated rates and timings of copper-lime, copper-lime-arsenical and sulphur dusts for the control of powdery mildew and leaf rust. These materials controlled disease, increased plant vigor, leaf retention, fruit number, fruit size and yields. Maximum yield increases as result of dusting was 320% (1931), 80% (1932), 125% (1933), 145% (1934), 87% (1935). The most effective timings for two applications were 80 percent blossom fall followed by a second dust 10 to 14 days later (Markin, 1943).

Materials and Methods

Wild blueberries in their fruiting year at two locations (Trial 1 - Sunbury County, Trial 2 – Gloucester County) were sprayed with five different fungicides to evaluate leaf spot and powdery mildew control. The trials consisted of a randomized complete block design with six treatments and five replications. Each plot consisted of a 2m by 6m solid stand of blueberry. Chemicals and rates applied were; myclobutanil (Nova 40W 340g/ha), propiconazole (Topas 250E 500ml/ha), flusilazol (Nustar 20DF 200 g/ha), cyprodinil (Vangard 75 WG 740g/ha) and fenbuconazole (Indar 75 WP 140g/ha). Applications were made on 16, 28 June, 9 July (Trial 1) and 18, 30 June, 13 July (Trial 2) with a backpack CO_2 sprayer delivering 250 L/ha at 270 kPa. Boom width was 1.5 m with four XRTeejet 11003VS nozzles spaced 50 cm apart.

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

Plots were rated for disease incidence on 26 July (Trial 1) and 28 July (Trial 2) by randomly selecting 25 leaves per plot. Leaves were rated for the presence of leaf spot and powdery mildew and the number of infected leaves recorded. Analyses of variance were performed on the data using Number Cruncher Statistical System, Version 6.0 (NCSS, Kaysville Utah). Before analyses, data were tested for homogeneity of variance and normality. Treatment means were compared using Fisher's protected least significance difference test, alpha 0.05.

Results

Some leaf infections were observed on 9 July (Trial 1) and 13 July (Trial 2) but disease incidence remained low for leaf spot and no powdery mildew was found at either site on the sampled leaves. Incidences of leaf spot on 26 July and 28 July are given in Table 1. No significant difference occurred between the any of the treatments at either site. There was little or no leaf discoloration or leaf drop at the time of harvest and fruit size was good.

Table 1. Control of leaf spot on blueberry

		Percent Disease	
Treatment	Rate	Trial 1	Trial 2
Untreated		22	26
Nustar 20DF	200 g/ha	25	26
Indar 75 WP	140g/ha	18	18
Vangard 75WG	740g/ha	16	22
Nova 40W	340g/ha	17	22
Topas 250E	500 ml/ha	14	17
		FSD0.05 =17.6	FSD0.05 = 15.2

References

Markin, Florence L. 1943. Blueberry diseases in Maine. *Maine Agricultural Experimental Station Bulletin* **419:** 404-417.

CRANBERRY INSECT PEST MONITORING IN NEW BRUNSWICK, 1999

DÉPISTAGE DES INSECTES NUISIBLES À LA CANNEBERGE AU NOUVEAU-BRUNSWICK 1999

C.M. Maund[1]

Partner / Partenaire: NB Cranberry Grower's Association / L'Association des producteurs de canneberges du Nouveau Brunswick

Abstract: Insect pests were monitored at cranberry (*Vaccinium macrocarpon*) sites in Oromocto West and Maugerville, New Brunswick during 1999 to determine when control methods would be required. Pheromone traps were used to monitor the following moths: blackheaded fireworm, *Rhopobota naevana* (Hübner); cranberry girdler, *Chrysoteuchia topiaria* (Zeller); sparganothis fruitworm, *Sparganothis sulfureana* (Clemens), cranberry fruitworm, *Acrobasis vaccinii* Riley. Results from Oromocto West: 1) blackheaded fireworm, trapped from 18 June to 26 August; 2) cranberry girdler, trapped from 18 June to 20 August; 3) cranberry fruitworm, trapped from 8 to 14 July; 4) sparganothis fruitworm, trapped from 14 July to 26 August. Results from trap captures provided information for timing of insecticide applications. Plants were sampled to determine the 50% out of bloom stage, which occurred on 4 July. This date was used for determining the appropriate time to apply a control measure for the cranberry fruitworm. Plants were sampled for damage by the cranberry tipworm, *Dasyneura vaccinii* (Smith). An average of 14.4% of plant tips, over the entire sampling period, had been damaged by the cranberry tipworm. Visual field inspections revealed no obvious signs of damage from other cranberry insect pests. A pre-harvest assessment, of three hundred cranberries on 27 September revealed 84.7% undamaged, 3.7% with fruitworm damage, 9.7% mushy from frost damage, 2% deformed from unknown causes. Results from Maugerville: 1) blackheaded fireworm, trapped from 18 June to 24 August; 2) cranberry girdler, trapped from 18 June to 13 August; 3) cranberry fruitworm, trapped from 8 to 19 July; 4) sparganothis fruitworm, trapped from 22 to 27 July. The 50% out of bloom stage occurred on 30 June. The cranberry tipworm was not present in samples. A pre-harvest assessment of three hundred berries revealed 98% undamaged, 0.33% with fruitworm damage, 1.33% mushy from frost damage, 0.33% deformed from unknown causes. Visual field inspections revealed no obvious signs of damage from other cranberry insect pests.

Résumé : Un dépistage d'insectes nuisibles a été réalisé en 1999 dans des plantations de canneberges (*Vaccinium macrocarpon*) à Oromocto Ouest et Maugerville (Nouveau-Brunswick) afin de déterminer le moment propice à une intervention. Des pièges sexuels ont permis de capturer des tordeuses des canneberges *Rhopobota naevana* (Hübner), des pyrales *Chrysoteuchia topiaria* (Zeller), des enrouleuses *Sparganothis sulfureana* (Clemens), et des pyrales des atocas *Acrobasis vaccinii* Riley. Les résultats s'établissaient comme suit à Oromocto Ouest : 1) des tordeuses des canneberges ont été capturées du 18 juin au 26 août; 2) des pyrales ont été capturées du 18 juin au 20 août; 3) des pyrales des atocas ont été capturées du 8 au 14 juillet; 4) des enrouleuses ont été capturées du 14 juillet au 26 août. Les résultats des prises permettent de déterminer le moment propice à l'application d'insecticide. Un échantillonnage des plants a révélé le stade où la moitié des fleurs sont tombées, soit le 4 juillet. Cette date a servi de repère pour déterminer le moment d'intervenir contre la pyrale des atocas. Un échantillonnage des plants a permis d'évaluer les dommages causés par la cécidomyie des pousses d'atocas *Dasyneura vaccinii* (Smith). En moyenne, 14,4 % des pousses ont été endommagées par la cécidomyie durant toute la période d'échantillonnage. Les inspections visuelles dans les champs n'ont pas révélé de signes évidents de dégâts causés par d'autres insectes nuisibles aux canneberges. Trois cents canneberges ont été examinées avant la récolte le 27 septembre : 84,7 % n'étaient pas endommagées, 3,7 % étaient endommagées par les vers, 9,7 % avaient des lésions aqueuses causées par le gel, et 2 % avaient une malformation de cause inconnue. Les résultats s'établissaient comme suit à Maugerville : 1) des tordeuses des canneberges ont été

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1/ Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

capturées du 18 juin au 24 août; 2) des pyrales ont été capturées du 18 juin au 13 août; 3) des pyrales des atocas ont été capturées du 8 au 19 juillet; 4) des enrouleuses ont été capturées du 22 au 27 juillet. Le stade où la moitié des fleurs sont tombées est survenu le 30 juin. Aucune cécidomyie des pousses d'atocas n'était présente dans les échantillons. Trois cents canneberges ont été examinées avant la récolte : 98 % n'étaient pas endommagées, 0,33 % étaient endommagées par les vers, 1,33 % avaient des lésions aqueuses causées par le gel, et 0,33 % avaient une malformation de cause inconnue. Les inspections visuelles dans les champs n'ont pas révélé de signes évidents de dégâts causés par d'autres insectes nuisibles aux canneberges.

Introduction

Integrated Pest Management (IPM) is an ecological approach to pest control based upon sound biological knowledge and principles. Cranberry (*Vaccinium macrocarpon*) IPM integrates biological, cultural, and chemical control practices to manage pest problems (DeMoranville *et al.* 1996). Monitoring for cranberry insect pests is an important aspect of Integrated Pest Management. Pheromone insect traps, sweep net sampling, and visual inspections are some of the scouting techniques used to monitor for insect populations. The purpose of this insect survey was to determine the extent and duration of cranberry insect pests at two sites, in Oromocto West and Maugerville, NB. The former is an established site, while the latter was planted in 1996. Information will allow the grower to apply control measures only when necessary.

A few of the more important cranberry insect pests, and their relevant damage to cranberry plants, are outlined below:

Cranberry Fruitworm. In the Maritime Provinces, the cranberry fruitworm (Pyralidae) is the most serious insect pest of the large cranberry (Wood 1981). The caterpillar of the cranberry fruitworm, *Acrobasis vaccinii* Riley, burrows into the top of the berry, near the stem and feeds on seeds and most of the pulp. It then moves on to other berries, and can feed on five to eight berries before completing development. Damaged berries turn red prematurely. Berries then dry and shrivel while remaining on the stem. By August and September the larva exits from the berry, and drops to the ground to overwinter as a larva inside a cocoon. Next spring, the larva pupates and the ensuing adult lays single eggs in the blossom end of berries. Egg hatch continues until early September. In Massachusetts, adults of the cranberry fruitworm occur from mid-June to late August (Roberts and Brodel 1985*a*). In Massachusetts, control for the cranberry fruitworm includes applying the first insecticide from 7 to 9 days after the bog has reached the 50% out of bloom stage and a second application 10 days after the first spray. The fruit is then sampled to determine whether or not a third spray is required (Sandler 1993).

Blackheaded Fireworm. First-generation larvae of the blackheaded fireworm (Tortricidae), *Rhopobota naevana* (Hübner), initially damages plants by mining leaves from the previous year's growth as well as the newly-formed terminal buds.

When new shoots appear, larvae web together several uprights at the plant tips. Damaged leaves are skeletonized and have a burnt appearance. Second-generation larvae occur from bloom to early berry set and feed on blossoms and berries. This generation is generally more damaging than the first one. A control should be applied if there is an average of 2 to 4 larvae per 25 sweeps of a sweep net if the bed has had infestations of blackheaded fireworm larvae. If infestations have not occurred and an average of 2 larvae are found per 25 sweeps then a control action is not necessary. First generation larvae may also be controlled by reflooding the site for 10 hours, providing that water can be quickly applied and removed to reduce the possibility of injury to flower buds. Reflooding is not recommended for control of second generation larvae due to resulting crop damage (Roberts and Brodel 1985*b*). In Massachusetts, the timing of a control measure is 10 days after the peak flight (Averill undated).

Cranberry Girdler. Larvae of the cranberry girdler (Pyralidae), *Chrysoteuchia topiaria* (Zeller), feed on bark and wood of the cranberry plant, causing girdling damage on the runners, which may become severed. Damage first appears in late fall. Often the extent of damage is not noticed until the following spring. Areas damaged by the cranberry girdler have no foliage (Roberts and Mahr 1982). In Massachusetts, cranberry girdler adults occur from the beginning of June until the end of July (Roberts and Brodel 1985*a*). In British Columbia, a control measure is recommended if the cumulative number of cranberry girdler moths is greater than 100 per trap by the end of a few weeks after adult emergence. Control may be by flooding, which will drown larvae that have not yet spun up cocoons, or by applying entomopathogenic nematodes (MAFF 1996). Regular resanding will also minimize problems with the cranberry girdler.

Cranberry Tipworm. Larvae of the cranberry tipworm (Cecidomyiidae), *Dasyneura vaccinii* (Smith), feed on the developing terminal leaves causing them to become cupped and eventually die. Most tips injured early in the season develop new growth but do not produce flowers. Tips attacked later in the season are likely to produce non-flowering uprights the following year. The larvae overwinter inside pupae on the surface of the bog (Roberts and Brodel 1985*a*). In eastern Canada, the first generation of larvae occurs in early June, the second generation occurs when the vines are in full bloom (Wood 1981). Regular resanding buries overwintering cocoons and helps to reduce population levels. Another control, in Maine, is to apply two insecticide sprays, one week apart, in spring when there is half an inch (approximately 10 to 15 mm) of new vegetative growth (Hedstrom *et al.* 1990).

Sparganothis Fruitworm. Larvae of the sparganothis fruitworm (Tortricidae), *Sparganothis sulfureana* (Clemens), feed on terminal; tips in the spring. Damaged leaves are webbed together. Second generation larvae feed on the berries, seldom devouring the whole berry. In Massachusetts, sparganothis fruitworm moths occur from early June to late July with the second generation of adults from early August until mid-October, when the first heavy frost occurs. Eggs are laid and hatch into young larvae which overwinter (Roberts and Brodel 1985*a*). In Massachusetts, a control measure is recommended two weeks after the peak flight, usually in the first three weeks of July, if the bed has had a history of Sparganothis infestations (Averill undated).

Materials and Methods

The cranberry pests were monitored at two cranberry sites: Oromocto West and Maugerville, both in Sunbury county. The Oromocto West site was approximately 4 hectares in area, and divided up into three beds. Beds 1 and 3 had the Early Blacks variety, while bed 2 had Howes (corrected from Maund 1998). The site in Maugerville was 52 acres in area and had been divided up into 22 beds. Cranberry plants were first planted at the Maugerville site in 1996 with the Stevens variety.

At Oromocto West, Scentry^{R}[2] and Trécé^{R} wing-type traps were used to monitor for the cranberry girdler, blackheaded fireworm, sparganothis fruitworm and cranberry fruitworm moths. Two traps were used for each moth species. Each trap was supplied with a pheromone lure for the respective moth species. Scentry^{R} brand lures were used for the first two moth species; Trécé^{R} brand lures were used for the other two. Traps were placed in the following manner: cranberry girdler traps in beds 2 and 3; blackheaded fireworm traps in beds 1 and 2; sparganothis fruitworm traps in beds 1 and 3; cranberry fruitworm in beds 2 and 3. Traps for the first two insects were set up at Oromocto West on 10 June and lures were replaced on 5 July and 9 August. Traps for the Sparganothis fruitworm and cranberry fruitworm were set up on 5 July and lures were replaced on 9 August. Traps were inspected twice a week until 26 August.

Insect populations at Oromocto West were not monitored with a sweep net as insects collected by sweeping in 1998 were well below threshold levels throughout the growing season (Maund 1998). However, the site was visually inspected two times a week, when inspecting traps, for signs of feeding activity.

Tipworm damage was determined by randomly collecting approximately 20 plant tips from each bed section twice a week from 10 June to 26 August. Plant tips were placed in plastic bags for later inspection of maggots, pupae, and the cupped terminal leaves, damage typical to that made by the cranberry tipworm.

A pre-harvest assessment was done on 27 September at Oromocto West. A one litre sample of cranberries was raked at random areas from each of the three beds. A random sample of 100 cranberries was then inspected from each of the three samples.

---

[2] The use of trade names in this publication is solely for identification purposes and does not imply endorsement of the products named or criticism of similar products not mentioned.

Per cent flowers out of bloom (% OOB) was calculated to determine the date when 50 % of the flowers were no longer in bloom. This was done as a pesticide application is recommended for the cranberry fruitworm 7 to 9 days after 50 % bloom, with a second application 10 days later (Sandler 1993). Per cent out of bloom was calculated according to Sandler (1993). Tips of cranberry plants were randomly sampled before and after 50 % bloom. Cranberry tips were then separated into the following stages: (1) unopened blossom, (2) flower, (3) pinhead stage [when petals have fallen off and the fruit is starting to set], (4) fruit. Per cent out of bloom (% OOB) was then calculated by the formula: {[stages 3 + 4] / [stages 1 + 2 + 3 + 4]} X 100 = % OOB.

Eight pheromone traps, identical to ones used at Oromocto West, were also set up at Maugerville, two for each moth species. Traps for the blackheaded fireworm, cranberry girdler, sparganothis fruitworm and cranberry fruitworm moth species were installed in beds 2 and 13; 4 and 14; 2 and 13; 4 and 14, respectively. Traps for the first two insects were set up at Maugerville on 10 June and lures were replaced on 5 July and 9 August. Traps for latter two were set up on 5 July and lures were replaced on 9 August. Traps were inspected twice a week until 26 August.

The per cent out of bloom date was also calculated for Maugerville to determine when to apply a control measure for the cranberry fruitworm.

Cranberry plant tips were sampled to check for the presence of the cranberry tipworm. Samples were collected twice a week from 10 June to 26 August. On each sample date, half of the sample was collected from beds 2 or 4, and the other half from beds 13 or 14. Sampling locations were rotated between dates. Forty tips were collected on each sampling date, except for the following, respective amounts and dates: 17 tips (26 June); 19 tips (10 & 24 June, 5 July); 20 tips (16, 24 & 26 August).

A pre-harvest assessment was done on 27 September at Maugerville. A one litre sample of cranberries was raked at random areas from each of three beds. A random sample of 100 cranberries was then inspected from each of the three samples.

The Maugerville site was visually inspected for the presence of insects and feeding damage. This site was not swept for insects as there were no obvious signs of feeding damage from insects.

Results and Discussion

Oromocto West.

Pheromone traps. Trapping results for Oromocto West are shown in Figure 1. Data is given as averages of results from two traps per moth species. Blackheaded fireworm moths were captured from 18 June to 26 August. Blackheaded fireworm populations peaked on 24 June and then decreased as Diazinon[3] had been applied on 20 June for the cranberry girdler. After a decrease, populations gradually increased until 8 July when Sevin XLR had been applied on 12 July for the cranberry fruitworm. Guthion, applied on 20 July for the cranberry fruitworm, also decreased blackheaded fireworm populations. There were no signs of damage from the blackheaded fireworm at Oromocto West.

Cranberry girdler moths were captured from 18 June to 13 August, and on 20 August. High numbers of cranberry girdler moths were seen flying on 18 June, therefore, Diazinon was applied on 20 June before the threshold of 100 moths caught per trap was reached. (The threshold was reached by 24 June, though, and trap captures would have included moths trapped between 18 June and 20 June, when the control measure had been applied.) Populations temporarily decreased, then rebounded to higher levels on 8 July. The application of Sevin XLR on 12 July caused populations to decrease by 14 July, and populations then returned to low levels for the rest of the season. Despite the high levels of cranberry girdler moths observed and trapped, there were no signs of damage from this pest. Reduction of weed levels would have helped in making the cranberry beds less attractive for these moths.

Cranberry fruitworm moths were trapped on 8 July (5 moths) and 14 July (3 moths). Population levels were very low due to the previously mentioned control measures. The cranberry fruitworm sprays had been properly timed, based upon percent out of bloom counts.

Sparganothis fruitworm moths were trapped at very low levels. Numbers of moths

---

[3] The use of trade names does not imply endorsement of products mentioned or imply that similar products are not effective. Labels rates and application procedures, etc. are to be followed according to label instructions.

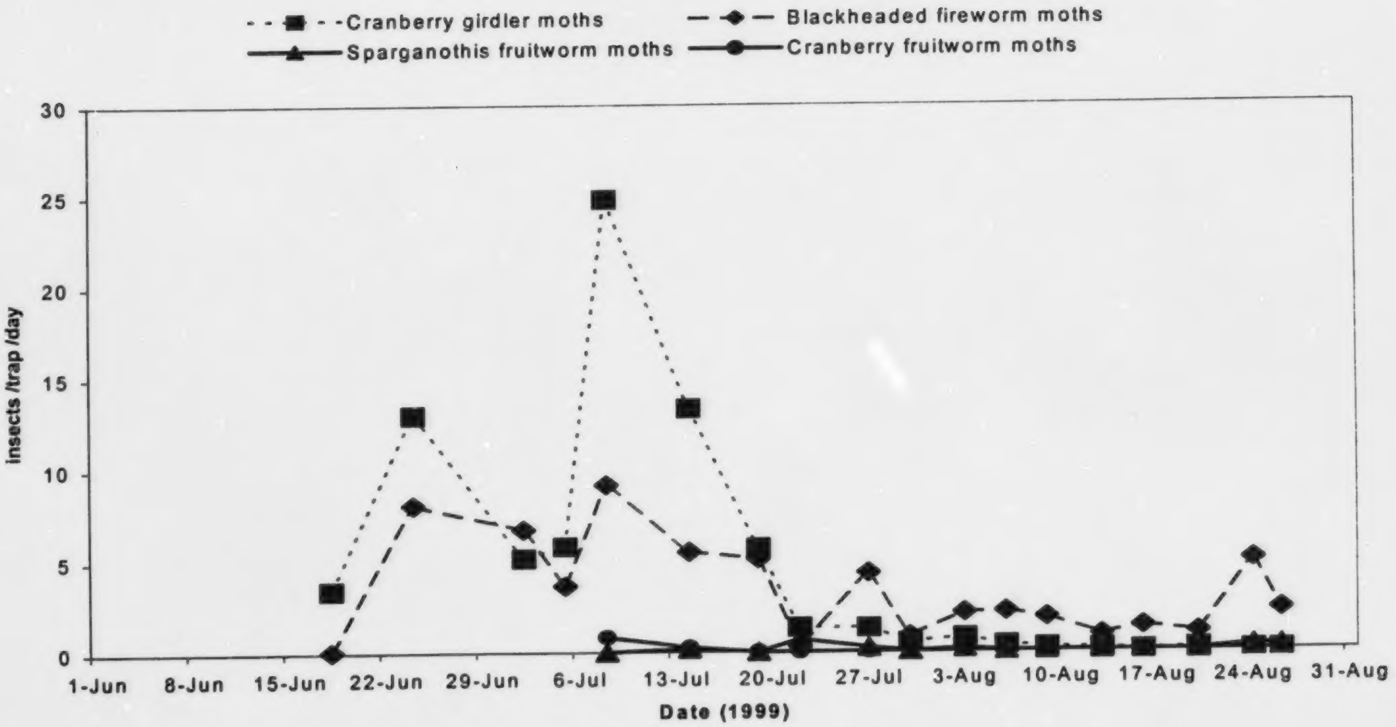


Figure 1. Average values of pheromone trap captures of insects/trap/day for cranberry girdler moths, blackheaded fireworm moths, sparganothis fruitworm moths and cranberry fruitworm moths, respectively, at a cranberry site in Oromocto, NB.

trapped on respective dates were: 2 (14 July); 4 (22 July); 2 (27 July); 1 (3 Aug); 1 (9 Aug); 2 (24 Aug); 1 (26 (Aug). This pest remained at insignificant levels, as in previous years.

Cranberry tipworm. Results of the percent of cranberry plant tips with damage from the cranberry tipworm are listed in Table 1.

Infestation levels were affected by pesticide applications, made on the following dates, for other pests: 20 June (Diazinon), 12 July (Sevin XLR), 20 July (Guthion). Infestation levels were also influenced by the tendency of infested plants to produce more uprights. High levels of damage started to appear by early July. There was no obvious trend in the average level of damage thereafter. The overall level of damage was 14.4%, which was similar to the overall level of 12.2% from 1998 (Maund 1998). Lower levels of damage would have occurred if a control measure had been applied early in the season when there was approximately 10 to 15 mm of new growth. (An early season control measure had been applied in 1998 for the tipworm, Maund 1998).

Life stages of the tipworm collected from tips are listed in Table 2. Plants with damage characteristic of tipworm injury (cupped leaves) but no insect present were not included in the table. In those samples, the tipworm would have been dislodged from the plant prior to sampling by people walking through the site, or by some other activity.

Tipworm maggots were first collected on June 10 to July 19, with highest levels on 2 July (Table 2). Small and large maggots were collected on 2 July. The first pupal stage was collected on 18 June, however, most were collected in early July. Small amounts of maggots and pupae were collected afterwards, therefore it was not possible to clearly determine population trends. Franklin (1948) reported that in Massachusetts there are two generations a year, with the first brood of maggots occurring in early June and the second brood occurring when the vines are in full bloom.

Per cent out of bloom. Cranberry plant tips were sampled at Oromocto West to determine the per cent out of bloom (%OOB). The %OOB rates and sampling dates were: 0% (24 June), 38.3% (2 July), 59.4% (5 July), respectively. The date calculated for the 50% OOB rate was 4 July, based upon calculating the rate of change of %OOB per day from 2 July to 5 July. The optimal time to apply the first pesticide application against the cranberry fruitworm was, therefore, 7 to 9 days after 4 July, being 11 to 13 July. Therefore, diazinon was applied on 12 July. A second control measure was made on 20 July, as a second one is recommended ten days later.

Table 1. Percent[4] of cranberry plant tips with cranberry tipworm damage at Oromocto West, NB

Date (1999)	Bed			
	1	2	3	Average
June 10	11.1	10.5	5.3	8.9
18	5	5	10	6.7
26	0	0	0	0
July 02	6.7	64.7	5	25
05	10	27.8	0	14
08	10	20	10	11.7
14	25	5	40	23.3
19	20	15	20	18.3
22	25	10	15	16.7
27	20	20	15	18.3
30	15	20	10	15
Aug 03	15	15	5	11.7
06	5	5	10	6.7
09	20	15	25	20
13	20	10	10	13.3
16	20	15	0	11.7
20	25	10	15	16.7
24	30	10	10	16.7
26	10	25	15	16.7
Average	15.8	15.6	12.0	14.4 (159/1108)

Pre-harvest assessments. A pre-harvest assessment was made at the Oromocto West site on 27 September. Results of 100 cranberries per bed were: Bed 1: 87 undamaged, 4 with hole from insects, 6 mushy from frost damage, 3 deformed from unknown causes. Bed 2: 85 undamaged, 4 with hole from insects, 8 mushy from frost damage, 3 deformed from unknown causes. Bed 3: 82 undamaged, 3 with hole from insects, 15 mushy from frost damage. Combined results were: 84.7% undamaged, 3.7% with hole from insects, 9.7% mushy from frost damage, 2% deformed from unknown causes. The 3.7% damage was from fruitworms. Although control measures had been applied at the correct times and fruitworm populations were low, better control would have likely been achieved if weed populations were

---

[4] N = 20 for each bed on each date, except for the following dates and tips, respectively, per bed. Bed 1: 10 June (18), 26 June (15), 2 July (15). Bed 2: 10 June (19), 26 June (18), 2 July (17), 5 July (18). Bed 3: 10 June (19), 26 June (17), 5 July (12).

Table 2. Number of infested cranberry plant tips[5] with maggot or pupal life stages of the cranberry tipworm at Oromocto West, NB

Date (1999)	Number of tips with:	
	Maggot	Pupa
June 10	4	0
18	1	1
26	0	0
July 02	12	0
05	1	0
08	2	2
14	1	1
19	1	2
22	0	0
27	0	0
30	1	0
Aug 03	1	1
06	0	0
09	1	0
13	0	0
16	0	1
20	0	1
24	0	0
26	0	0

[5] N = 60 for each sample date (except N = 56, 50, 52, 50 for 10 June, 26 June, 2 July, 5 July, respectively). Data is not included for plants with cupped leaves from tipworm damage when the insect was not found on the plant.

markedly reduced, allowing for better pesticide coverage. Frost damage could have been prevented by irrigation at night when conditions were below freezing.

Maugerville.

Pheromone traps. Trapping results for Maugerville are shown in Figure 2. Data is given as averages of results from two traps per moth species. Blackheaded fireworm moths were caught on traps from 18 June to 24 August. Highest trap captures occurred on 2 and 8 July, then decreased as Guthion had been applied for the cranberry fruitworm on sections 6-22 (8 July) and sections 1-6 (12 July).

Life stages of the tipworm collected from tips are listed in Table 2. Plants with damage characteristic of tipworm injury (cupped leaves) but no insect present were

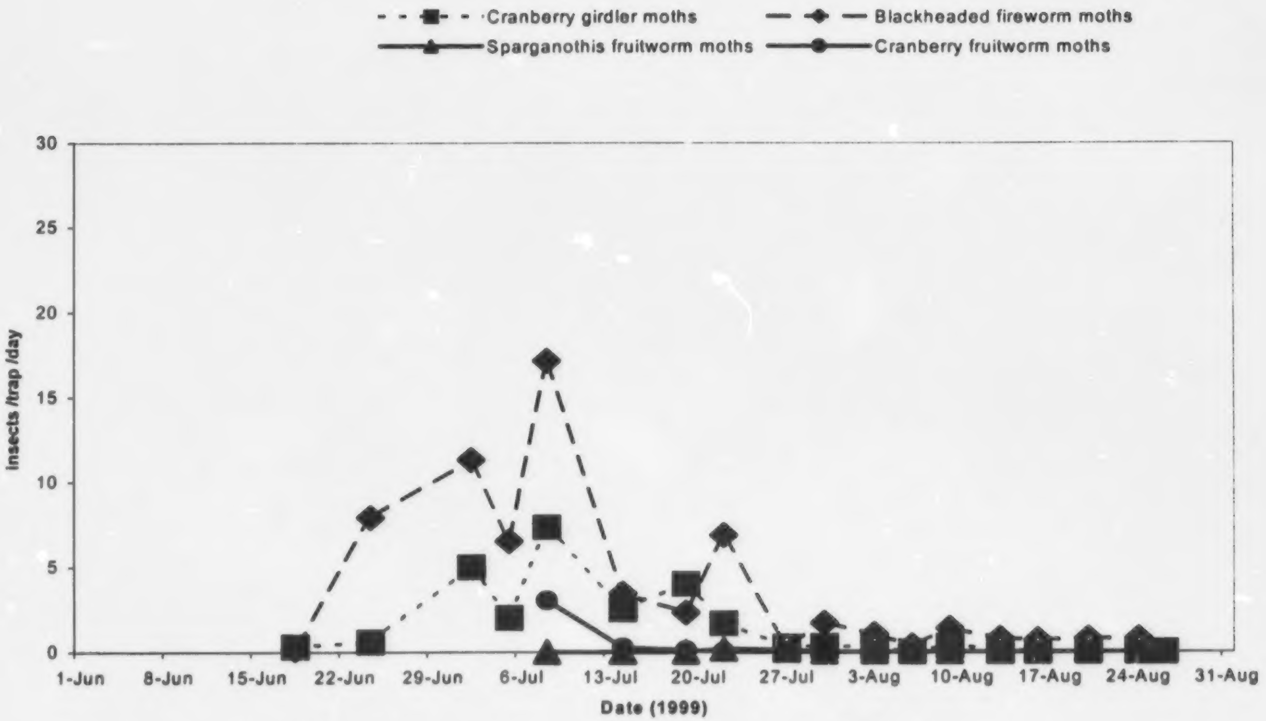


Figure 2. Average values of pheromone trap captures of insects/trap/day for cranberry girdler moths, blackheaded fireworm moths, sparganothis fruitworm moths and cranberry fruitworm moths, respectively, at a cranberry site in Maugerville, NB.

not included in the table. In those samples, the tipworm would have been dislodged from the plant prior to sampling by people walking through the site, or by some other activity.

Tipworm maggots were first collected on June 10 to July 19, with highest levels on 2 July (Table 2). Small and large maggots were collected on 2 July. The first pupal stage was collected on 18 June, however, most were collected in early July. Small amounts of maggots and pupae were collected afterwards, therefore it was not possible to clearly determine population trends. Franklin (1948) reported that in Massachusetts there are two generations a year, with the first brood of maggots occurring in early June and the second brood occurring when the vines are in full bloom.

Per cent out of bloom. Cranberry plant tips were sampled at Oromocto West to determine the per cent out of bloom (%OOB). The %OOB rates and sampling dates were: 0% (24 June), 38.3% (2 July), 59.4% (5 July), respectively. The date calculated for the 50% OOB rate was 4 July, based upon calculating the rate of change of %OOB per day from 2 July to 5 July. The optimal time to apply the first pesticide application against the cranberry fruitworm was, therefore, 7 to 9 days after 4 July, being 11 to 13 July. Therefore, diazinon was applied on 12 July. A second control measure was made on 20 July, as a second one is recommended ten days later.

Blackheaded fireworm populations further decreased after 22 July due to the Guthion application for the cranberry fruitworm on 23-24 July. There were no obvious signs of damage from the blackheaded fireworm.

Cranberry girdler moths were caught on traps from 18 June to 3 August and from 9 to 13 August. A control measure was not required for the cranberry girdler as populations had not reached 100 moths per trap within a few weeks of initial emergence. There were no obvious signs of damage from the cranberry girdler.

Cranberry fruitworm moths were trapped from 8 to 19 July. Highest trap captures occurred on 8 July, then decreased to very low levels due to the two previously mentioned control measures.

A control measure was not required for sparganothis fruitworm moths as only two moths were trapped, one on 22 July and one on 27 July.

Cranberry tipworm. No cranberry tipworm specimens (or related damage) were found in any of the samples at Maugerville.

Per cent out of bloom. Cranberry plant tips were sampled at Maugerville to determine the per cent out of bloom (%OOB). The %OOB rates and sampling dates were: 21.9% (24 June), 46.7% (29 June), 59.9% (2 July), respectively. The date calculated for the 50% OOB rate was 30 June, based upon calculating the rate of change of %OOB per day from 29 June to 2 July. The optimal time to apply the first pesticide application against the cranberry fruitworm was, therefore, 7 to 9 days after 30 June, being 7 to 9 July. The first application of guthion began on 8 July and was completed on 12 July. The second application of guthion was applied from 23-24 July. A second application is recommended ten days later.

Pre-harvest assessments. A pre-harvest assessment was made at Maugerville on 27 September. Results of 100 cranberries per bed sampled were: Bed 2: 98 undamaged, 2 mushy from frost damage. Bed 4: 97 undamaged, 1 with hole from insects, 2 mushy from frost damage. Bed 11: 99 undamaged, 1 deformed from unknown causes. Combined results were: 98% undamaged, 0.33% with hole from insects, 1.33% mushy from frost damage, 0.33% deformed from unknown causes. Irrigation had been applied to protect cranberries from frost damage.

Conclusions

At Oromocto West, blackheaded fireworm populations were maintained at low levels due to control measures applied for other pests. There were no signs of damage from this pest. A control measure was applied for the cranberry girdler before the recommended threshold as high populations had been observed. Populations were initially reduced to low levels. Higher populations were then controlled with sprays for another cranberry pest. Consequently, damage was not observed for this pest. Reduction of weed levels would have made the area less attractive for cranberry girdler moths. Two control measures were applied for the cranberry fruitworm, based upon percent out of bloom crop phenology. Populations were prevented from reaching high levels, as indicated by pheromone trap counts. Sparganothis fruitworm population levels were very low and were incidentally reduced by control measures for the cranberry fruitworm. Damage from fruitworms was 3.7%. This level may be reduced if weed populations were much lower, allowing for a more effective pesticide coverage on the fruit. Damage from frost was 9.7%. Frost damage could have been prevented by irrigation practices at nights when temperatures were below freezing. Cranberry tipworm damage averaged 14.4%. Although this is a difficult pest to control, a pesticide application, made when there was approximately 10 to 15 mm of new growth, would have reduced tipworm population levels.

At Maugerville, highest levels of blackheaded fireworm moths occurred in early July, then decreased due to control measures applied for another cranberry pest. There were no signs of damage from the blackheaded fireworm. A control measure for the cranberry girdler was not required as a control measure had been applied for another pest before cranberry girdler populations reached threshold levels. Damage from the cranberry girdler was not observed. Two control measures were applied for the cranberry fruitworm, based upon percent out of bloom crop phenology. Populations were prevented from reaching high levels, as indicated by pheromone trap counts. Sparganothis fruitworm populations were at very low levels. Damage from fruitworms was at very low level of 0.33% indicating control measures had been applied at the appropriate times, along with other proper management practices. The cranberry tipworm was not observed in samples.

Acknowledgements

The author would like to thank the cranberry operators at the Oromocto West and Maugerville sites for their cooperation and interest in the monitoring program.

References

Averill, A.L. _______ . Sex Pheromone Traps. Fact sheet. Univ. of Massachusetts. Cranberry Experiment Station, Massachusetts.

DeMoraineville, C., H. Sandler and T. Bicki. 1996. Best Management Practices Guide for Massachusetts Cranberry Production - Integrated Pest Management. Fact sheet. Univ. of Massachusetts. Cranberry Experiment Station, Massachusetts.

Franklin, H.J. 1948 . Cranberry Insects in Massachusetts. Bulletin No. 445. (64 pp.) Massachusetts Agricultural Experiment Station. Univ. of Massachusetts.

Hedstrom, W., B. Wittchen and J. Harker. 1990. Cranberry Agriculture in Maine: Opportunities and Challenges. PP. 56 - 63. Maine.

MAFF (Ministry of Agriculture, Fisheries and Food). 1996. Berry Production Guide for Commercial Growers 1996/97 edition. Province of British Columbia, Victoria, BC, 104 pp.

Maund, C.M. 1998. Cranberry insect pest monitoring in New Brunswick, 1998. *Adaptive Research Reports* **20:** 195-209.

Roberts, S.L. and C.F. Brodel. 1985*a*. Major Cranberry Insect Pests. Fact sheet. Univ. of Massachusetts. Cranberry Experiment Station, Massachusetts.

Roberts, S.L. and C.F. Brodel. 1985*b*. The blackheaded fireworm. Fact sheet. Univ.of Massachusetts. Cranberry Experiment Station, Massachusetts.

Roberts, S.L. and D.L. Mahr. 1982. The Cranberry Girdler. Fact sheet. Univ. of Wisconsin-Madison, Wisconsin.

Sandler, H.S. 1993. Cranberry Fruitworm Management. Calculating Percent out of Bloom and Fruit Inspection. Fact sheet. Univ. of Massachusetts. Cranberry Experiment Station, Massachusetts.

Wood. G.W. 1981. Growing Cranberries. Publication 1282/E. Agriculture Canada, Ottawa. pp. 23 - 27.

EVALUATION OF THE PERFORMANCE OF FUNGICIDES ON GRAIN YIELD AND LEAF DISEASES ON SPRING WHEAT - NEW BRUNSWICK 1999

ÉVALUATION DE L'EFFET DE FONGICIDES SUR LE RENDEMENT GRAINIER ET SUR LES MALADIES FOLICOLES DU BLÉ DE PRINTEMPS - NOUVEAU-BRUNSWICK 1999

D.F. Walker[1], P.D. Sandeson[2] and/et A.O.M. Smith[1]

Partner / Partenaires: New Brunswick Soil and Crop Improvement Association, Novartis Crop Protection Canada Inc. / Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick et Novartis Crop Protection Canada Inc.

Abstract: In 1999 a collaborative project between Novartis Crop Protection Canada Inc., the New Brunswick Department of Agriculture and Rural Development and the New Brunswick Soil and Crop Improvement Association was established to evaluate the performance of Tilt, Stratego, Flint and Quadris on leaf diseases in spring wheat. A randomized complete block design was set up in the Hartland area of New Brunswick on May 4. There were ten treatment plots ($14 m^2$) replicated four times. The application of the fungicides at varying rates (62.5, 125, and 250 g ai/ha) occurred either at Zadocks growth stage (GS) 32-37, GS 55, or split, half at GS 32- 37 and half at GS 55. Yield data and visual ratings on crop injury were collected. Yields ranged from 4.7 – 4.2 T/ha. Hectoliter weights ranged from 89.2 – 83.8 kg/Hl. The thousand kernel weights ranged from 40.3 – 38.3 grams. In the summer of 1999 weather conditions were extremely dry and disease pressure was low. No disease was evident throughout the study. Therefore, there was no significant difference between the treatments.

Résumé : Un projet a été réalisé en 1999 grâce à un partenariat entre Novartis Crop Protection Canada Inc., le ministère de l'Agriculture et de l'Aménagement rural du Nouveau-Brunswick et l'Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick, afin d'évaluer l'effet des fongicides Tilt, Stratego, Flint et Quadris sur les maladies folicoles du blé de printemps. Le 4 mai 1999, un dispositif en blocs aléatoires complets à été établi dans la région de Hartland (Nouveau-Brunswick). Les dix parcelles de traitement de $14 m^2$ chacune étaient répétées quatre fois. Les fongicides ont été appliqués à diverses doses (62,5, 125 et 250 g de matière active par hectare) aux stades de croissance 32-37 de l'échelle Zadocks, au stade 55 et en application fractionnée (la moitié de la dose au stade 32-37 et l'autre moitié au stade 55). Des données sur le rendement et les résultats de l'évaluation visuelle des dommages à la culture ont été consignés. Les rendements variaient de 4,7 à 4,2 t/ha. Le poids d'un hectolitre variait de 89,2 à 83,8 kg. Le poids de mille grains variait de 40,3 à 38,3 grammes. À l'été 1999, le temps était extrêmement sec, et l'incidence des maladies était faible. Aucune maladie n'a été observée durant l'étude. Par conséquent, on n'a pas relevé d'écart important entre les traitements.

Introduction

In a maritime climate cereal diseases can have a large influence on grain yield and quality and ultimately on the profitability of the sector. The main diseases are spot and net blotch, fusarium and scald for barley and mildew, *Septoria nodorum* and *Septoria tritici* and fusarium for wheat. Most diseases attack the

---

[1] Livestock and Livestock Feed Branch, NBDARD, Fredericton, NB / Direction de l'élevage et de l'alimentation des animaux, MAARNB, Fredericton, NB

[2] New Brunswick Soil & Crop Improvement Association, Fredericton, NB / Association pour l'amélioration du sol et des cultures du Nouveau-Brunswick, Fredericton, NB

photosynthetic capacity of the plant resulting in lower yield mainly due to reduced kernel weight. Disease induced lower kernel weight usually causes shriveled kernels, reduced hectolitre weight which ultimately lowers the final grain grade. A few diseases including fusarium attack the kernel which produce toxins which also cause the grain to be down graded .

Plant health products have been developed that reduce cereal diseases resulting in lower yield and quality losses. The purpose of this field trial was to evaluate new fungicides at several rates and timings compared to presently recommended products.

Materials and Methods

Spring wheat (cv. AC Walton) was planted in Hartland, NB on the 4 May with a Wintersteiger Oyjord plot seeder. The row spacing was 15 cm and plot size was 2 x 7 m. The trial consisted of a randomized complete block design with four replications. A broadcast application of 90 kg N/ha was applied to all plots on the 13 May. All plots received an additional application of 25 kg N/ha on 28 June. Dyvel (1.25 L/ha) was applied on the 28 May with a Horstein plot sprayer for weed control. Fungicide treatments, product rates, growth stages and application dates are presented in Table 1. All fungicides were applied using a CO_2 hand held sprayer with a two meter boom. Visual ratings (1 - 100%) on crop injury were collected on the last two emerged leaves pre-application (3 June) and 7 (11 June), 14 (18 June), and 21(24 June) days following the first application. This procedure was repeated after second application (1 July) with examination of last two emerged leaves and head on 8 July, 15 July and 21 July. Plots were harvested with a Hege 140 plot combine. Area harvested was 1.5 x 7 m. Seed was cleaned and reported at 15% moisture. Plant heights, thousand kernel weights and hectoliter weight were also collected. Data was subjected to an analysis of variance and means separation by the LSD test (p=0.05).

Results and Discussion

Unusually dry conditions during the growing season resulted in low disease incidence and disease pressure. There were no detectable levels of disease in any of the plots including the control during the growing season. The lack of any response to fungicide application was due to unusually dry conditions. There was no significant difference in any of the measured parameters (Table 2) including grain yield, test weight or thousand kernel weight as a result of fungicide application.

Table 1. Treatments, product rates, growth stages and application dates

Treatment Number	Treatment	Rate	Zadoks Growth Stage	Date of Application
1	Untreated	-	-	-
2	Tilt 250EC	125	GS 32-37	4 June
3	Tilt 250EC	62.5	GS 32-37	4 June
4	Stratego 250EC	62.5/62.5	GS 32-37	4 June
5	Flint 125EC	62.5	GS 32-37	4 June
6	Stratego 250EC	62.5/62.5	GS 55	1 July
7	Tilt 250EC	125	GS 55	1 July
8	Stratego 250EC	62.5/62.5; 62.5/62.5	GS 32-37; GS 55	4 June; 1 July
9	Tilt 250EC	125; 125	GS 32-37; GS 55	4 June; 1 July
10	Quadris 250SC	250	GS 55	1 July

Table 2. Yield and agronomic characteristics of the Novartis spring wheat fungicide study, Hartland, N.B. 1999

Treatment Number	Treatment	Rate (g ai/ha)	Yield (T/ha)	Test wt. (kg/Hl)	TKW (g)	Plant height (cm)
1	Untreated	-	4.5	84.6	39.5	84.1
2	Tilt 250EC (GS 32 – 37)	125	4.3	84.1	39.1	83.8
3	Tilt 250EC (GS 32 – 37)	62.5	4.2	84.1	38.3	84.6
4	Stratego 250EC (GS 32 – 37)	62.5/62.5	4.5	83.8	39.9	84.9
5	Flint 125EC (GS 32 – 37)	62.5	4.5	84.1	39.4	83.3
6	Stratego 250EC (GS 55)	62.5/62.5	4.5	89.2	39.7	84.3
7	Tilt 250EC (GS 55)	125	4.6	83.8	39.4	86.1
8	Stratego 250EC (GS 32-37; GS 55)	62.5/62.5; 62.5/62.5	4.6	83.9	40.3	85.7
9	Tilt 250EC (GS 32 - 37; GS 55)	125; 125	4.7	84.2	39.8	87.6
10	Quadris 250EC (GS 55)	250	4.4	84.5	39.9	86.6
LSD (0.05)	-	-	0.6	4.4	1.9	4.5
CV (%)	-	-	9.7	3.6	3.3	3.7

Conclusions

Low disease pressure during the growing season resulted in a non response from any fungicide treatment. It was therefore impossible to evaluate the efficacy of fungicide applications on spring wheat yield and leaf diseases.

Acknowledgments

The authors wish to express thanks to the New Brunswick Soil and Crop Improvement Association for providing administrative services for this project. Appreciation is also extended to summer staff Sara Hiscock, Nadine Othberg and Nick Ingram. Funding for this project was provided by the Strategic Partnership Development Fund and Novartis Crop Protection Canada Inc. Roy Culberson provided plot land, land preparation and storage facilities for this project.

MONITORING OF INSECT POPULATIONS IN POTATO FIELDS IN 1999

DÉPISTAGE DES POPULATIONS D'INSECTES DANS LES CHAMPS DE POMMES DE TERRE EN 1999

Guy Bernard[1]

Abstract : Aphid populations were generally low during the 1999 season. Green peach aphid populations increased throughout the month of August. Flea beetle populations have been on the rise for some years now and threshold levels were exceeded in mid-June with several fields reporting in excess of 500 holes/ 14 leaflets. Damage levels that were excessive were also noted in some fields in the fall. Colorado potato beetle populations exceeded the threshold during two consecutive weeks in 1999. Larval numbers were highest during week 4 and 5 (week of June 21 and June 28) and reached an average level of 82.29 larvae/30 plants during this period. Infestations of corn borers were reported during the 1999 season with damage levels of 1 or more holes in 80% of the stems in some fields. Infestations of cutworms, leafhoppers, tarnished plant bugs and spider mites were also reported in addition to the usual wireworm infestations.

Résumé : Les populations de pucerons étaient généralement peu nombreuses durant la campagne agricole de 1999. Les populations de pucerons verts du pêcher ont augmenté durant le mois d'août. Les populations d'altises sont en hausse depuis quelques années, et les seuils d'intervention ont été dépassés à la mi-juin dans plusieurs champs, où l'on a relevé plus de 500 piqûres par 14 feuilles. On a aussi relevé des taux de dommage excessifs dans certains champs à l'automne. Les populations de doryphores de la pomme de terre ont dépassé les seuils d'intervention durant deux semaines consécutives en 1999. Le nombre de larves a atteint un sommet durant les semaines 4 et 5 (semaines du 21 juin et du 28 juin), et l'on comptait en moyenne 82,29 larves par 30 plants durant cette période. Des infestations de pyrales du maïs ont été signalées durant la campagne de 1999, et il y avait au moins un trou par tige, dans 80 % des tiges, dans certains champs. On a aussi dépisté des infestations de vers gris, de cicadelles, de punaises ternes et de tétranyques, en plus des infestations habituelles de vers-fil-de-fer.

Introduction

The most common insects in potato fields in New Brunswick are the Colorado potato beetle, several species of colonizing aphids and the potato flea beetle. Colorado potato beetles are chewing insects. They can cause substantial reductions in yield if defoliation is extensive and occurs during a sensitive growth period.

Aphids are sucking insects. Many are vectors of virus diseases and as such, they are of particular concern to seed growers since tolerances for viruses are low in seed crops. Aphids can also reduce yields if infestations are severe.

Potato flea beetles are small insects which chew holes in potato leaves. Yield reductions are most likely to occur only if populations are very high late in the season.

---

[1] Potato and Horticulture Branch, 39 Barker Lane, Wicklow, NB E7L 3S4 / Direction la pomme de terre et horticulture, 39 Barker Lane, Wicklow, NB E7L 3S4

In 1999, insect populations were monitored weekly in 35 fields in the potato belt. A sample area was established in each field early in the spring and data were collected from within the plot for a period of 13 weeks.

Aphid populations were estimated by counting the number of winged and wingless aphids of each species on the whole lower surface of one bottom, one middle and one top leaf per plant on a total of 30 plants per plot.

Colorado potato beetle infestations were evaluated by counting the number of larvae, egg masses and adults in each plot on a total of 30 whole plants.

Flea beetle damage was evaluated by counting the number of feeding holes on the terminal leaflet of the fourth leaf from the top of one stem on 14 plants per plot.

The purpose of this data collection in potato fields was to provide growers with timely and easy-to-understand information that would help them better schedule insecticide applications and avoid unnecessary treatments. Field infestation data as it pertains to aphids has also been an essential complement to the aerial monitoring of aphids with yellow pan traps.

A new system of handling data and producing reports was designed in 1999. Using a Dell laptop computer and a Hewlett Packard Deskjet 340 portable colour printer, the Excel statistical and graphing software package was used to provide growers with easy to understand information in the field immediately after monitoring (Fig.1).

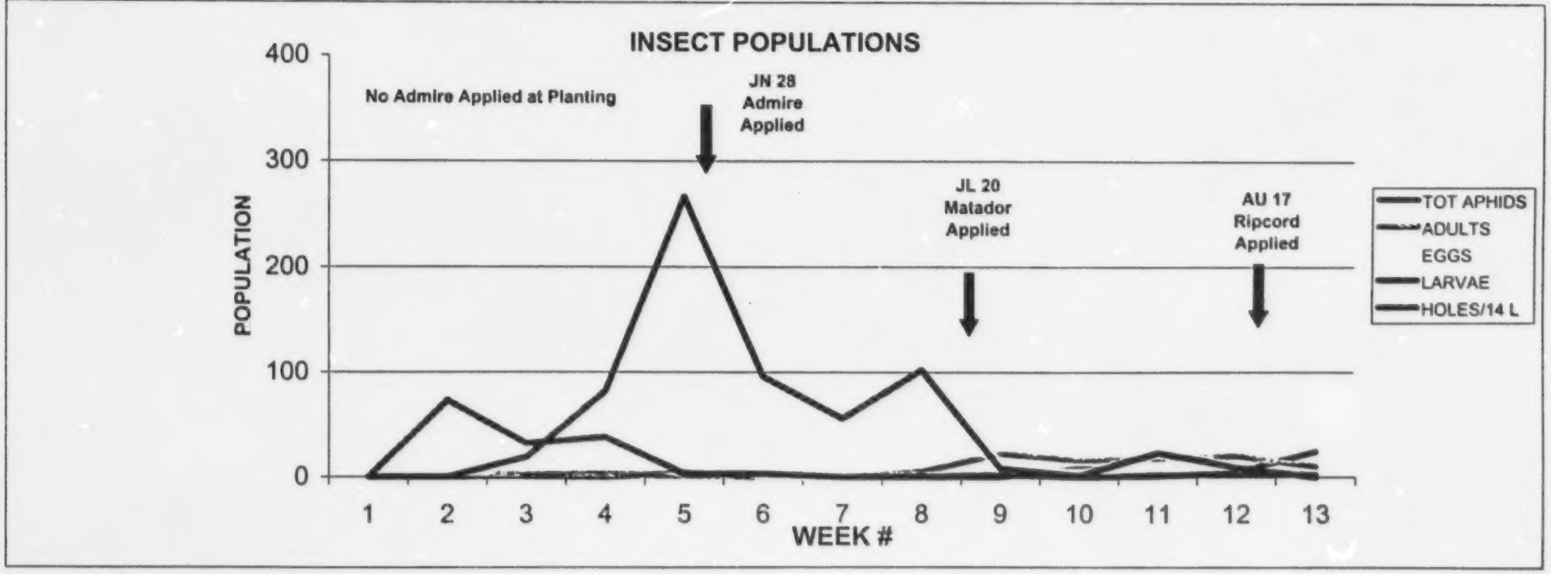
Data collected from the 35 fields sample were also used to provide information to all growers on field populations of insects. This information was available through the use of a toll-free telephone answering service and personal letters to producers.

Summary of 1999 Insect Monitoring Season: The percentage of fields infested with potato flea beetles was high as usual in the first part of the season. Spring peak infestation levels reached 100 % on weeks 2 and 3 (week of June 7 and June 14). Average damage threshold levels of 200 holes/14 leaflets were surpassed during week 3 with several fields reporting in excess of 500 holes/14 leaflets. Infestation levels gradually diminished to 57 % by week 8 (week of July 19), as overwintering adults died-off. As new adults emerged from the ground afterwards, infestation levels reached 96% by week 11 (week of August 9). Damage levels in the fall were highest during the two last weeks of the season (week of August 16 and August 23). One field reported damage levels of 1075 holes/14 leaflets during this period.

1999 INSECT MONITORING PROGRAM

GROWER # 4 processing field
GROWER NAME

		APHIDS / 90 LEAVES								COLO BEETLES / 30 PLANTS			FLEA B.	INSECTICIDES	FUNGICIDES
WEEK	MM/DD	WGP	GP	WPO	PO	WBU	BU	% INF	TOT APHIDS	ADULTS	EGGS	LARVAE	HOLES/14 L		
1	JN 01	?	?	?	?	?	?	?	?	?	?	?	?		
2	JN 09	0	0	0	0	0	0	0	0	5	5	0	73		JN 11, Dithane
3	JN 16	0	0	0	1	0	0	3.33	1	2	17	19	32		JN 19, Dithane
4	JN 21	0	0	0	0	0	0	0	0	3	12	82	38		
5	JN 28	0	0	0	4	0	0	6.66	4	1	15	266	3	JN 28, Admire	JN 28, Dithane
6	JL 05	0	0	0	0	0	0	0	0	0	0	96	3		JL 03, Ridomil
7	JL 12	0	0	0	0	0	0	0	0	0	0	56	0		JL 12, Dithane
8	JL 19	0	0	0	0	0	0	0	0	5	0	102	0	JL 20, Matador	JL 20, Dithane
9	JL 26	0	0	0	0	0	0	0	0	22	6	8	2		JL 27, Dithane
10	AU 02	0	6	1	0	0	1	9.99	8	16	5	1	0		AU 04, Dithane
11	AU 09	0	2	0	0	0	3	6.66	5	18	8	23	1		
12	AU 16	0	5	0	0	0	0	6.66	5	20	5	9	4	AU 17, Ripcord	AU 17, Dithane
13	AU 23	0	24	0	0	0	0	19.98	24	10	2	0	2		
TOTAL TO DATE		0	37	1	5	0	4	53.28	47	102	75	662	158		



TRESHOLDS : APHIDS- rapid increase........COLORADO B.- 60 adults or larvae.......FLEA B. - 200 holes

Aphid populations were generally low in potato fields during the 1999 season. The Buckthorn and potato aphids were the first to colonize potato fields. The highest average infestation level recorded were 11.29 aphids/sample for the Buckthorn aphid and 13.08 aphids/sample for the potato aphid. The highest average infestation levels recorded were 16.75 aphids/sample for the green peach aphid. Green peach aphid populations increased in potato fields through the month of August

Colorado potato beetle populations were moderate during the 1999 season, as larvae numbers exceeded the action threshold of 60/30 plants during only 2 weeks of the season. The highest number of adults was reported during weeks 2 and 3 (week of June 7 and June 14). The highest average number recorded during that period was 7.45 adult beetles/30 plants. The highest number of egg masses occurred during week 3 and 4 (week of June 14 and June 21). The highest average number recorded during that period was 20.55 egg masses/30 plants. Larvae numbers were highest during week 4 and 5 (week of June 21 and June 28) and reached an average level of 82.29 larvae/30 plants during this period. The action threshold was exceeded in more than 50 % of the fields monitored during that period.

European corn borers were present in many potato fields during the 1999 season. Infestations were most severe in the southern part of the potato belt, from Woodstock to Florenceville. Some of the fields monitored were infested at a rate of 1 or more holes per stem in 80% of the stems inspected. Surprisingly, good to excellent yields were reported in some of these fields.

There were also infestations of cutworms, leafhopper, tarnished plant bugs and spider mites during the 1999 season in addition to the usual wireworm infestations.

The following graphs (Fig. 2 to 6) depict the weekly status of insect populations in 35 potato fields during the summer of 1999. Although strongly biased by insecticide applications, they have nevertheless been included for the record and to provide a continuing basis for comparisons.

Figure 2. Colorado potato beetles 1999

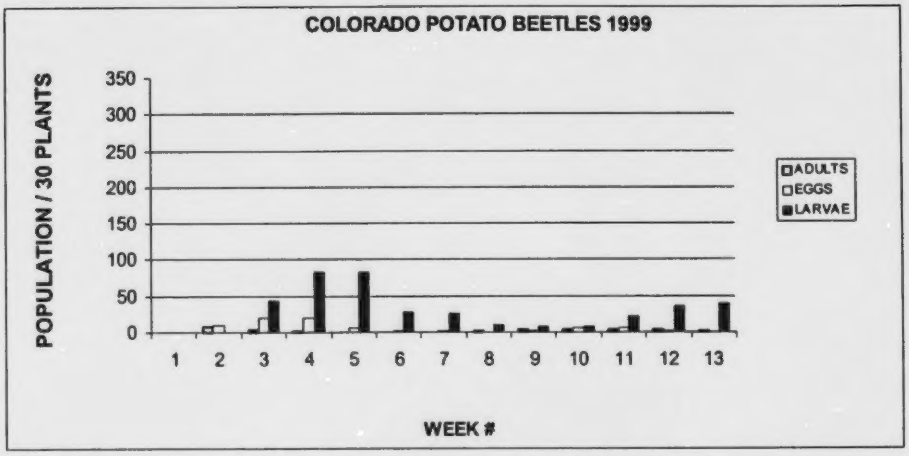


Figure 3. Flea beetles 1999

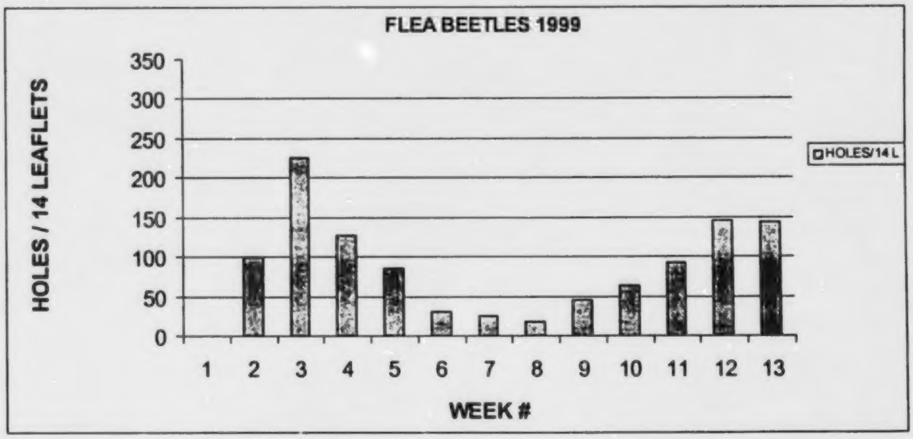


Figure 4. Green peach aphids 1999

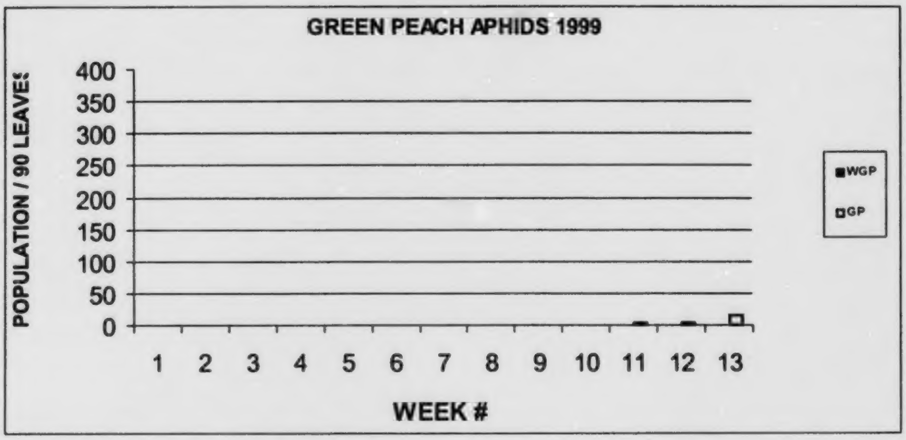


Figure 5. Buckthorn aphids 1999

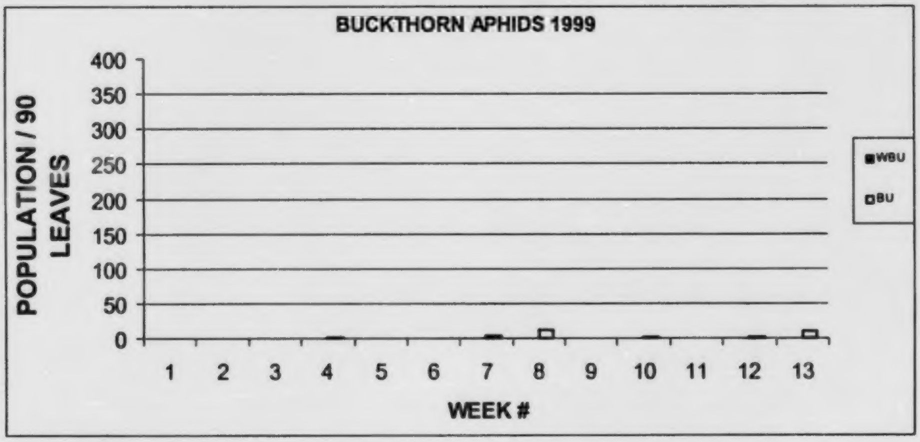
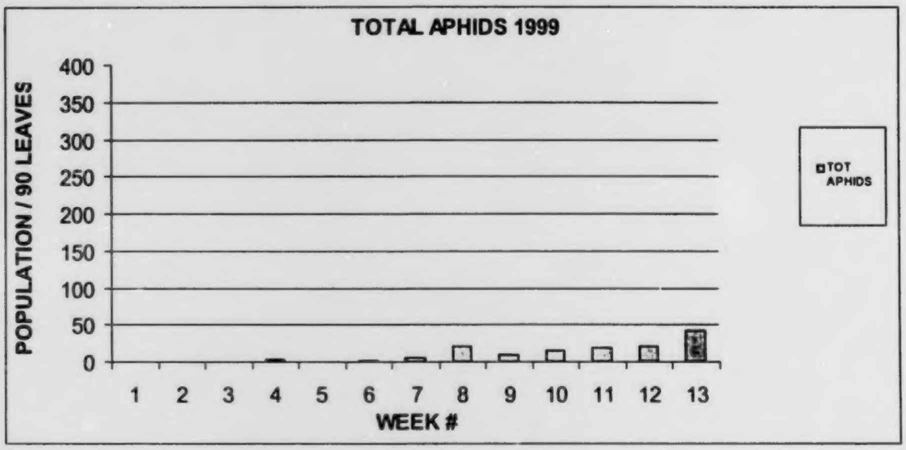


Figure 6. Total aphids 1999



AERIAL MONITORING OF POTATO INFESTING APHIDS IN NEW BRUNSWICK IN 1999

DÉPISTAGE AÉRIEN DES PUCERONS INFESTANT LA POMME DE TERRE AU NOUVEAU-BRUNSWICK EN 1999

Guy Bernard[1]

Abstract: Green peach aphid catches in yellow pan traps were much lower than average during the 1999 season. Buckthorn aphid catches and common potato aphid catches were much higher than average. Other aphid catches were very low.

Résumé : Les captures de pucerons verts du pêcher ont été de beaucoup sous la moyenne en 1999. Les captures de pucerons du nerprun et de pucerons communs de la pomme de terre ont été plus élevées que la normale; tandis que celles des autres pucerons ont été faibles.

Introduction

Aphids, mainly because of their ability to transmit virus diseases, are an important pest of potatoes. The green peach aphid (Mp), in particular, is the major vector of PLRV (leafroll) and an efficient vector of PVY (mosaic). Both of these diseases account for a substantial proportion of the seed field rejections each year in New Brunswick. Aphid populations have been monitored extensively in the province since 1974 and a warning service based on aphid catches in yellow pan traps has been available to potato producers ever since.

In 1999, 17 seed potato growers operated a total of 34 yellow pan traps in the province; while students operated 35 traps and Bon Accord 16. Contents of yellow pan traps are collected by growers in seed fields and by scouts in table and processing potato fields. As part of the aphid advisory service, weekly reports on aphid flights, based on these trappings, are sent to cooperating farmers, inspectors and others during the growing season. Information is also made available to all growers through the use of a toll-free telephone answering service, and personal letters to producers.

Since the inception of the program in 1974 students had collected aphid samples from seed growers at the farm gate and brought them to the Agricultural Resource Centre in Wicklow for identification. This practice was discontinued in 1999 and producers were asked to arrange for transportation of their own samples to the Centre.

---

[1] Potato and Horticulture Branch, 39 Barker Lane, Wicklow, NB E7L 3S4 / Direction de la pomme de terre et horticulture, 39, allée Barker, Wicklow, NB E7L 3S4

The practice of setting mandatory topkill dates for seed potato crops, which was established in New Brunswick in 1981, was discontinued during the 1990 season. Since then, potato producers have simply been advised to apply a topkiller to seed crops as soon as possible after the occurrence of significant green peach aphid catches in their region.

Results

The first catches of green peach aphids for the 1999 season occurred on August 3 in Tilley, St-Andre and Bon Accord; only one green peach aphid was caught in each trap . On August 19, a few more were caught in Bon Accord and Bloomfield. No significant catches of green peach aphids occurred during the remainder of the season (Fig 5).

Catches of green peach aphids were lower than average during the 1999 season (Fig 1). The average catch was 0.01 aphids/trap/week compared to the median catch of 0.25 for the preceding 25 years of data collection.

Catches of the buckthorn aphid were higher than average in 1999 (Fig 2). The average catch was 0.69 aphids/trap/week compared to the median catch of 0.20 for the preceding 25 years of data collection. The highest numbers were recorded in late June and late July (Fig 5).

Catches of the common potato aphid in yellow pan traps were higher than average in 1999 (Fig 3). Average catches were 1.58 aphids/trap/week compared to the median catch of 0.34 for the preceding 25 years of data collection. The highest numbers were recorded in late June and August (Fig 5).

Catches of other aphids in yellow pan traps were low in 1999 (Fig 4). Average catches were only 3.38 aphids/trap/week compared to the median catch of 9.06 for the preceding 25 years of data collection. The highest numbers were recorded in August (Fig 5).

Fig. 1. Green peach aphid flights

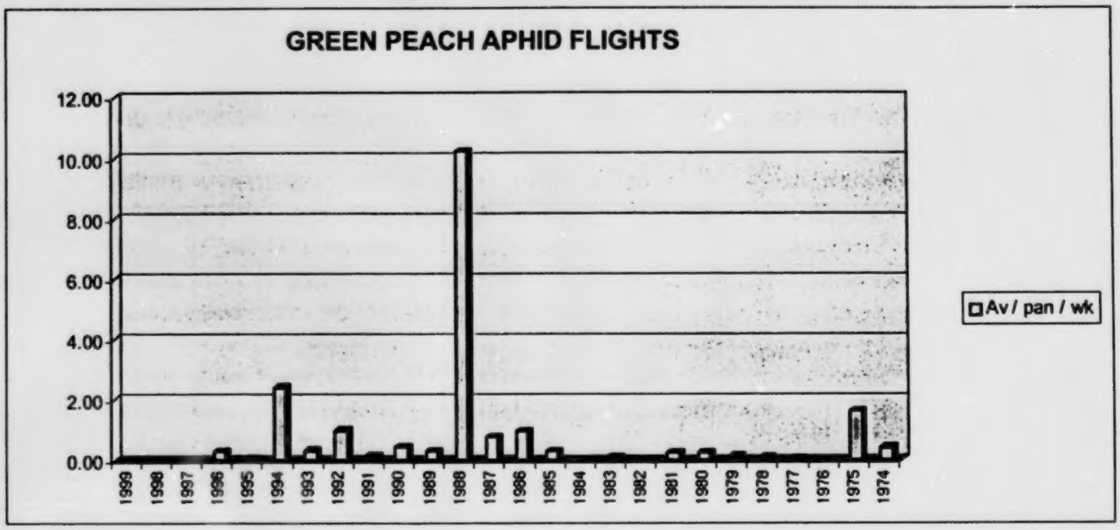


Fig. 2. Buckthorn aphid flights

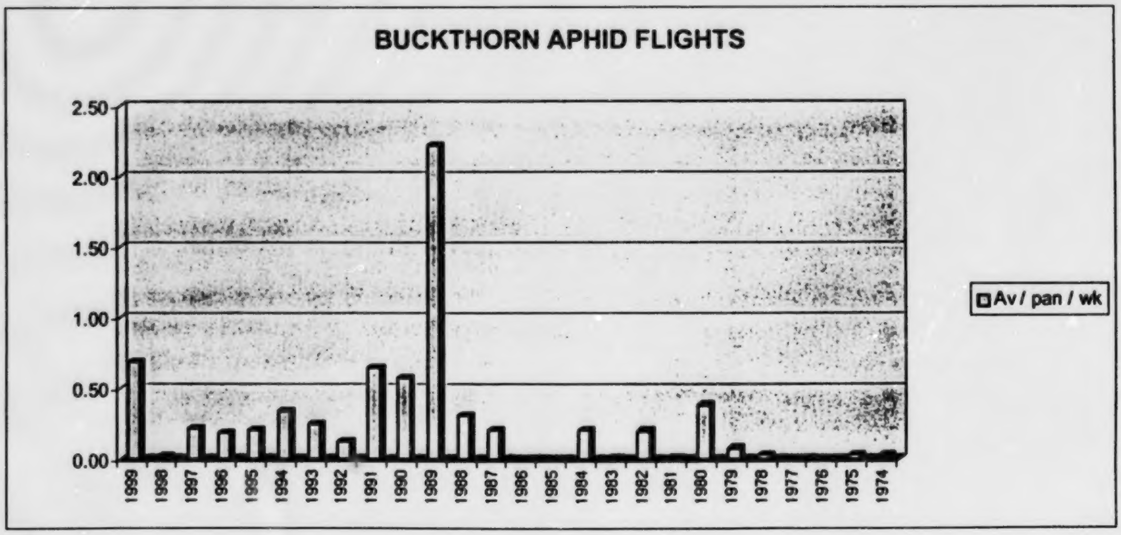


Fig. 3. Potato aphid flights

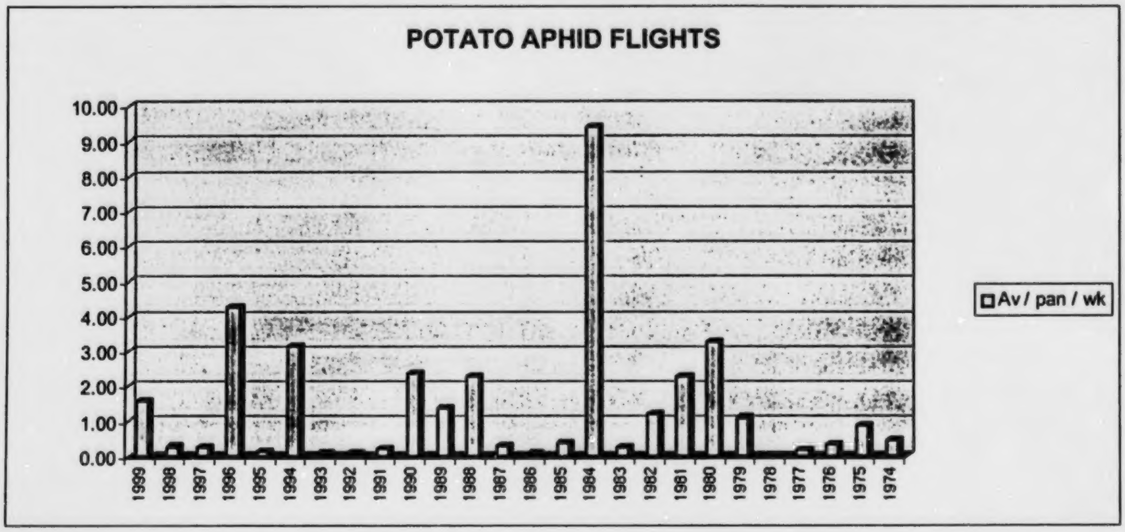
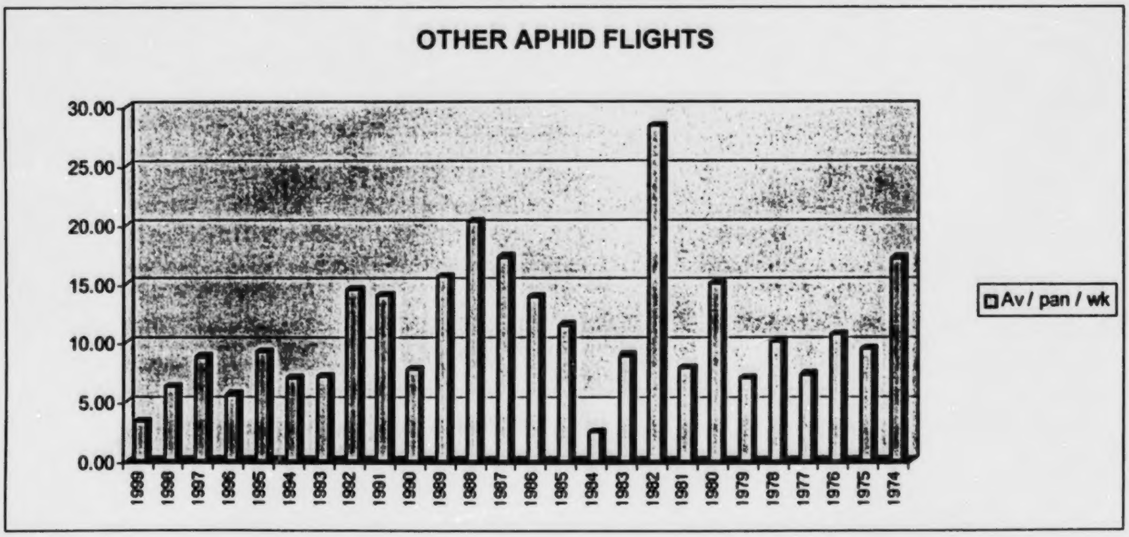


Fig. 4. Other aphid flights



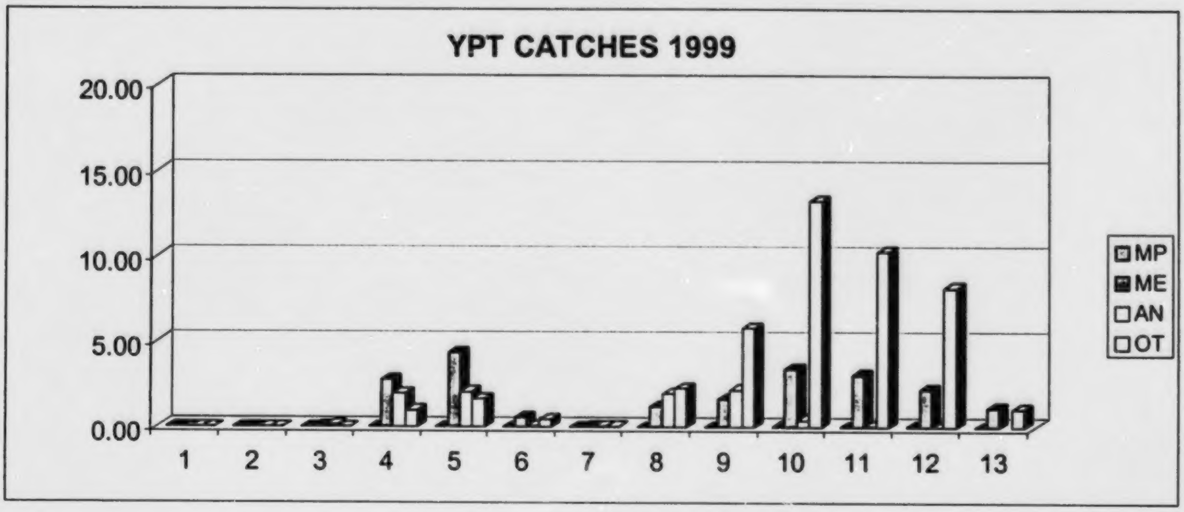


Fig. 5. Yellow pan trap catches, 1999

CONTROL OF COMMON LEAF SPOT IN STRAWBERRY

LUTTE CONTRE LA TACHE COMMUNE DANS LES FRAISIERS

K. Lynch[1]

Abstract: Control of common leaf spot (*Mycosphaerella fragariae)* was evaluated on two commercial strawberry farms in Central New Brunswick. Fungicides evaluated were; propiconazole (Topas 250E 500ml/ha), myclobutanil (Nova 40W 340g/ha), chlorothalonil (Bravo 500 2.0 L/ha), chlorothalonil (Bravo 500 3.5 L/ha, flusilazol (Nustar 20DF 200 g/ha) and dodine (Cyprex 65W 740g/ha). Applications were made on 17, 26 August, and 06, 17, 27 September. On 9 November 78 percent of leaves in the untreated controls (trials combined) were infected with common leaf spot. The percent disease control for the two trials combined for the various treatments were; Topas 89%, Nova 76%, Bravo 2.0L 70%, Bravo 3.5L 69%, Nustar 62% and Cyprex 56%.

Résumé : On a procédé à une évaluation de la lutte contre la tache commune (*Mycosphaerella fragariae)* dans deux fraiseraies commerciales du Centre du Nouveau-Brunswick. Les fongicides alors étudiés étaient le propiconazole (Topas 250E 500 ml/ha), le myclobutanil (Nova 40W 340 g/ha), le chlorothalonil (Bravo 500 2,0 L/ha), le chlorothalonil (Bravo 500 3,5 L/ha), le flusilazol (Nustar 20DF 200 g/ha) et le dodine (Cyprex 65W 740 g/ha). Les applications ont été faites les 17 et 26 août et les 6, 17 et 27 septembre. En date du 9 novembre, 78 p. 100 des feuilles des fraisiers non traités (essais combinés) étaient infectées par la tache commune. Les pourcentages de fongicides des deux essais combinés pour les divers traitements sont les suivants : 89 p.100 de Topas, 76 p. 100 de Nova; 70 p. 100 de Bravo 2,0 L, 69 p. 100 de Bravo 3,5 L, 62 p. 100 de Nustar et 56 p. 100 de Cyprex.

Introduction

Common leaf spot caused by *Mycosphaerella fragariae* is a major disease of strawberries grown in New Brunswick. High incidence of leaf spotting after renovation reduces plant vigor and fruit production. Plants stressed by leaf spot and other pests such as cyclamen mites yield poorly and appear to be more susceptible to winter injury. Fruit hulls are highly susceptible to leaf spot and infections prior to harvest discolor the hulls and reduces marketability.

Materials and Methods

Strawberry (cv. Kent) in its first picking year, (York County - Trial 1), and strawberry (cv. Kent) in its planting year (Carleton County - Trial 2) were sprayed with six different fungicides to evaluate leaf spot control. These commercial fields were chosen based on a high incidence of naturally occurring leaf spot on 10 August. The trials consisted of a randomized complete block design with four replications. Each plot consisted of a single matted row, 5 m in length. Chemicals and rates applied were; chlorothalonil (Bravo 500 2.0 L/ha), chlorothalonil (Bravo 500 3.5 L/ha), myclobutanil (Nova 40W 340g/ha), propiconazole (Topas 250E 500ml/ha), dodine (Cyprex 65W 740g/ha), flusilazol (Nustar 20DF 200 g/ha).

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

Applications were made on 17, 26 August, and 06, 17, 27 September with a back-pack CO_2 sprayer delivering 500 L/ha at 270 kPa. Boom width was 0.9 m with four Teejet D2 cone nozzles (#25 cores) spaced 30 cm apart.

Plots were rated for disease incidence on 9 November by randomly selecting four subplots each consisting of a 25 cm diameter circle. All leaves within the subplot were counted and number infected with leaf spot recorded. Data from the four sub plots was combined and converted to percent leaves infected per plot. Analyses of variance were performed on the data using Number Cruncher Statistical System, Version 6.0 (NCSS, Kaysville Utah). Before analyses, data were tested for homogeneity of variance and normality. Treatment means were compared using Fisher's protected least significance difference test, alpha 0.05.

Results

Some leaves had leaf spot infections prior to the first spray. New infections were not observed until 19 October. Incidences of leaf spot on 9 November are given in Table 1.

Excellent control of leaf spot was achieved with Topas applied at 500 ml/ha. The combined level of control for the two trials for this treatment was 89 percent. In these trials some leaves were infected before the first sprays were applied and close examination of new foliage indicated that this treatment gave near 100 percent control of infections initiated subsequent to the first spray. All treatments had significantly less leaf spot then the untreated control in both trials. Cyprex 65W, which is currently recommended for leaf spot control in Atlantic Canada, gave only fair control of this disease. Bravo treatments applied on 17 August resulted in some phytotoxicity at both locations. Foliage developed a purple discoloration that remained for the duration of the trial. New foliage that formed after 17 August and contacted by subsequent sprays did not develop any signs of phytotoxicity. Topas would appear to be an excellent addition to integrated pest management for strawberry in this region. Additional trials required to support a User Requested Minor Use Label Expansion for this product should be carried out.

Table 1. Control of common leaf spot on strawberry

		Trial 1		Trial 2	
Treatment	Rate	% Disease	% Control	% Disease	% Control
Untreated		79	-	77	-
Cyprex 65W	740 g/ha	35	56	33	57
Nustar 20DF	200 g/ha	18	77	40	48
Bravo 500	2.0 L/ha	24	70	24	69
Bravo 500	3.5 L/ha	29	63	19	75
Nova 40W	340g/ha	14	82	23	70
Topas 250E	500 ml/ha	8	90	9	88
		FSD0.05 = 11.2		FSD0.05 = 13.0	

WEED MANAGEMENT IN CRANBERRY

LUTTE CONTRE LES MAUVAISES HERBES DANS LES CANNEBERGIÈRES

K. Patterson[1] and/et M. G Sampson[1]

Partners /Partenaires : The New Brunswick Cranberry Growers Association and the Nova Scotia Cranberry Growers Association / L'Association des producteurs de canneberges du Nouveau-Brunswick et l'Association des producteurs de canneberges de la Nouvelle-Écosse.

Abstract: Trials to evaluate approximately 60 weed control products for crop tolerance in cranberries were conducted between December 1,1999 and March 31,2000 in the greenhouses of the Department of Environmental Sciences at the Nova Scotia Agricultural College in Truro, Nova Scotia. Separate trials to evaluate weed control products as post-emergent treatments, pre-emergent treatments and dose response treatments were conducted bringing the total number of treatments applied to approximately 85. Crop tolerance was visually rated on a scale of 0-9, where 0 = complete kill and 9 = complete tolerance of the crop to the herbicide. Evaluations were carried out at crop rating intervals of 3-5, 7-14, 21-28 and 56-63 days after treatment. A preliminary examination of the crop tolerance data revealed that 35 out of 58 post-emergent herbicide treatments rated favorably for crop tolerance. This study has identified those products which have potential for use in cranberries. An environmental assessment of these products is being conducted to reduce the number of candidate products for field evaluations in the summer and fall of 2000.

Résumé : L'essai d'environ 60 herbicides pour déterminer la tolérance des canneberges est actuellement réalisé dans les serres du département des sciences environnementales du Collège d'agriculture de la Nouvelle-Écosse, à Truro (Nouvelle-Écosse). Des essais distincts permettent d'évaluer les herbicides après la levée, avant la levée et selon la dose, et le nombre total de traitements s'élève à 85 environ. La tolérance de la culture sera déterminée visuellement sur une échelle de 0 à 9 (0 = destruction complète de la culture; 9 = tolérance complète de la culture à l'herbicide). Les évaluations doivent être effectuées à diverses périodes après le traitement (de 3 à 5 jours, de 7 à 14 jours, de 21 à 28 jours et de 56 à 63 jours après le traitement). L'étude permettra de désigner les herbicides qui pourraient être utilisés dans les cannebergières.

Introduction

Cranberries represent an excellent opportunity for Atlantic Canadian agriculture, not only in the area of fresh berry production but also in the area of value added products. In order for this crop to be viable, it is important to identify any constraints that can limit the viability of this crop. During the summer of 1999, a survey and preliminary studies looking at weeds and crop growth in cranberries were conducted in cranberry plantations in the Annapolis Valley and the Debert area of Nova Scotia (Chaffey and Sampson, unpublished). This study identified some of the major weed problems that our cranberry growers face and demonstrated the effect that weeds have on slowing down growth and establishment of cranberry vines. Tours of New Brunswick cranberry plantations allowed for the concerns of producers there to be represented in the objectives of the proposed research project. Cranberry production is growing in Nova Scotia. There are 45 acres currently in production and 50.5 newly planted acres (Webster, 1999). In New Brunswick, industry growth is even more dramatic with 75 acres harvested this season, 155 acres newly planted, 50 acres in their second year of growth and 10 acres in the third year of growth for a total of 290 acres of cranberry under cultivation (McCully, 1999).

---

[1] Nova Scotia Agricultural College / Collège d'agriculture de la Nouvelle-Écosse

Of the many concerns that are associated with the production of cranberries, pest management issues are some of the most pressing, most limiting and most complex facing the industry today. For cranberry producers in Atlantic Canada, weed control is one of the most critical components of current pest management strategies. Left uncontrolled, weeds will compete for nutrients, moisture, light and space. This, in turn, delays and/or prevents establishment of cranberry plants in new plantations. Competition from weeds reduces cranberry yields significantly (Swanton, et al. 1993). Weed pressures are very high in Nova Scotia because most plantings are surrounded by pasture, woodlands or farm fields. The source of the vines and management of the cranberry beds by using sand and water offers an excellent opportunity for new weeds to be continually introduced.

Good weed management when bogs are first being established is essential. Growth of the vines will be greatly reduced if weeds are not controlled when the plants are young or before the vines have covered the bog. Competition for space is also an issue as weeds occupy sites that normally would be available for the spread of vines. It will therefore take longer to produce a well established bed that will produce enough fruit for a profitable harvest. Maintaining healthy, vigorous vines is a very important measure of weed control (Eck 1990). Weak vines are poor weed competitors in the ecological niche created by the drainage, levelling, sanding, fertilization, and irrigation of the field (Dana 1990). The key to maintaining healthy vines are good management practices such as good soil drainage, proper water management, and obtaining clean vines and sand.

There is currently a need for new weed management strategies as well as information that can be made available to growers to enable them to make adequate decisions on their weed management strategies (Sandler and Bewick 1998). Availability of weed control products is limited to just a few herbicides.

Products registered for use in the planting year consist of glyphosate (Roundup®, Touchdown® or Glyphos®) as a wick or wiper application; napropamide (Devrinol®) to control grass weeds and some broadleaf weeds; fluazifop-p-butyl (Fusilade II®) for control of quackgrass in non-bearing bogs and some annual grasses and sethoxydim

(Poast®) to control quackgrass, rice cutgrass and annual grasses (Anon., 1999).

As cranberry plants become more established, they generally become more tolerant to herbicide applications. Even with increased tolerance, the number of registered chemicals for use in established cranberry beds remains limited, glyphosate (Roundup®, Touchdown® or Glyphos®) as a wick or wiper application; dichlobenil (Casoron®) for control of many annual and perennial broadleaf and grass weeds, and certain sedges and rushes; napropamide (Devrinol®) for the control of grass weeds including rice cutgrass and some broadleaf weeds; sethoxydim (Poast®) for control of quackgrass, rice cutgrass and other annual grasses; and agricultural weed killer no. 1 (Mineral Oil) for the control of cottentop and control of cloudberry in peat bogs (Anon. 1999).

Producers and extension specialists are faced with many limitations, including a lack of information relevant to Atlantic Canada concerning weed management strategies and a lack of easily accessible reference material necessary for making informed managerial decisions. In addition there is conflicting information contained on weed control product labels based on where the product has originated from. Differences on labels of products from the U.S. and from Canada leave extension personnel and growers concerned that appropriate rates and timing of applications may not be administered accurately. The availability of sufficient tools, including a broader range of chemical controls, also limits the success of these weed management strategies. *Although there are some products available, they do not provide the level of control desired, particularly in the first few years of crop establishment those available often injure the cranberry plants. There is a need for safe and effective products that can be included in a weed control system.

Weed control is considered one of the biggest challenges facing Atlantic Canadian growers at this stage in the development of the industry (Lewis, 1998). It is estimated that even with the best existing management options available a crop production loss of 10% to 25%, depending on the composition of the weed population, occurs in most fields annually. There is a need to further exploit research and development in regions where the cranberry industry is more established and there has been more work done in pest management, particularly in the area of Integrated Weed Management (IPM) (Sampson, 1999). IPM is already practiced to some extent by many producers if only through monitoring on a regular basis or by using thresholds. The need to widen and enhance IPM programs is seen as being of paramount importance to the industry. The adoption of this technology would ease the reliance on scarce registered chemical controls, expand grower knowledge and management choices and respond to issues of environmental impact. Herbicides are part of current IPM strategies but few are available and the development of herbicide resistance in weed populations is a concern. Research must address these issues, while at the same time, provide the tools necessary for the production of a high quality crop.

Great support for the project has been demonstrated by industry as evidenced by the cooperation of Nova Scotia growers during the summer of 1999 when a survey and preliminary studies were carried out in their plantations. New Brunswick producers have shown great interest and have promised some financial support for the project. The Nova Scotia Cranberry Growers Association donated a supply of cranberry vines so that large scale herbicide screening could begin this past winter in the NSAC greenhouses in preparation for full scale field trials that were initiated in the Spring of 2000. Extension specialists have also been very supportive in the development of this research program.

The development of new, safer products for use in cranberry production, through a program of screening, evaluation and submission of results to Health Canada and the Pest Management Regulatory Agency, has never been done in Atlantic Canada. Registration of pest control products is strictly monitored and success in doing so is determined by a recognition by these agencies of the need for these products by the industry as a whole. Similar research is being conducted in a few North American institutions and has just begun to yield limited results. Support by the Atlantic Canadian region will assist in demonstrating need and industry priorities to these agencies, greatly increasing the probability of achieving broad industry objectives.

Specific weed management strategies developed through the research program will be incorporated into a more comprehensive integrated pest management program. Strategies for weed control must compliment those for other pests to produce an effective, production oriented and environmentally friendly program.

Experience gained from herbicide evaluation efforts conducted for the blueberry industry could benefit the cranberry industry as they are closely related crops. Not only are they in the same plant family and have similar growth habits, they grow in areas considered to be environmentally sensitive and require management practices and pest control products that do not persist in the environment.

The benefits to Atlantic Canadian cranberry producers that will be attained as a result of the completion of the project include identified effective and safe weed control products that will be going through the process of registration for cranberries with Health Canada, an improved crop management program specific to the needs of the cranberry and improved support from extension and research through increased networking.

The impact the project will have upon completion of the registration process for new, safer herbicides are many. More effective control of problem weeds will be achieved at an earlier stage of development of a cranberry bog resulting in diminished production losses. There will be a decreased need for labour intensive wiper applications of herbicide, for roguing and for pre-harvest mowing to facilitate harvesting, thus lowering production costs. The availability of more effective herbicides would reduce the number of applications that are made over the course of a growing season, again reducing production costs and risk to the environment.

The research will make a valuable contribution to the cranberry industry in North America. Resource materials and improved management systems developed for immediate use by local growers will become available to the industry as a whole. Links with research institutes and producer driven research across North America will strengthen research efforts locally and open avenues to additional funding sources.

Materials and Methods

On a newly established study population of cranberry plants, a randomized complete block experimental design, replicated 4 times, with a plot size of 25 x 25 cm was used, consisting of a control (no herbicide application) and approximately 60 herbicides with no current registration for use on cranberries. This study evaluated the phytotoxic effects of these herbicides on cranberry vines. Cranberry vines were established in the greenhouse and allowed to overcome any transplant shock prior to treatment applications. Crop tolerance was visually rated on a scale of 0-9, where 0 = complete kill and 9 = complete tolerance of the crop to the herbicide. Evaluations were carried out at crop rating intervals of 3-5 days after treatment (DAT), 7-14 DAT, 21-28 DAT and 56-63 DAT. Separate trials to evaluate weed control products as post-emergent treatments, pre-emergent treatments and dose response treatments were conducted bringing the total number of treatments applied to approximately 85. This study identified those products which have potential for use in cranberries.

Results and Discussion

The determination of optimum techniques for propagation of cranberry cuttings showed that successful cuttings can be obtained at lengths as short as 10 cm. The length of time required for roots to begin forming on newly planted cuttings was consistently seen to be 14-15 days under controlled, moist, greenhouse conditions. Cranberry cuttings selected for the trials were on average approximately 30 cm long and contained a minimum of three uprights per cutting. After transplanting the cuttings, the young vines tend to die back and when roots form then new growth begins to appear as branch shoots on the uprights or as shoots originating from buried vine material. The time required for the trial population of young cranberry plants to produce enough new growth so that accurate visual ratings for crop tolerance could be made was greater than had been anticipated. As a result the majority of trial treatments were applied behind schedule and visual observations of regrowth are still being conducted. Sufficient time remains for observations to be completed and interpreted for selection of treatments for field trials to be carried out this summer.

A list of products which have been applied as post-emergent treatments or post-emergent dose response treatments can be found in Appendix 1.

Table 1 shows the preliminary crop tolerance data for the post-emergent treatments, up to and including 21-28 DAT. Only the treatments that maintain an acceptable crop tolerance rating of 7-9 throughout the rating period will be considered for field evaluation. These are the herbicides that exhibit little or no damage to the cranberry vines. Of the 58 treatments tested, 35 were found to be acceptable.

Pre-emergent treatment applications for the purpose of these trials is described as herbicide applications made immediately prior to root formation on transplanted cuttings of cranberry vines. It is known that the cuttings under greenhouse conditions begin to form roots in 14-15 days after transplanting. Treatments were applied 12 days after transplanting the cuttings to ensure that the products had not dissipated prior to the formation of roots on the cuttings. The transplanting of cuttings for this trial has taken place and the treatments were applied on March 24, 2000. Treatments were delayed so that progress in the establishment of the post-emergent treatment cranberry trial population could be monitored and to allow for some of the products being shipped from the agri-chemical industry partners to arrive. In addition to visual ratings of crop tolerance, root development will be assessed in the event that there is no regeneration of above ground plant material. Appendix 2 lists the pre-emergence treatment applications. Due to time constraints, insufficient data had been obtained from the pre-emergent trial to include in the preliminary report.

From the final results of the greenhouse screening trial, it is expected that approximately 12-15 post-emergent herbicide treatments will be carried over to the field trial. This list will be determined through an environmental assessment procedure, examining herbicide solubility, persistence, environmental sensitivity and other related factors. Treatments which are not selected for initial field trials will be retained for further greenhouse testing or incorporation in future field studies.

Table 1. Crop tolerance data for post-emergent herbicide treatments

Trt No.	Treatment Name	Rate	Rate Unit	Treatment Evaluation Interval		
				3-5 DAT	7-14 DAT	21-28 DAT
1	Control			9a	9a	9a
2	Blazer	2.5	L/HA	9a	8b	7c
3	AAtrex Nine-0	1.65	KG/HA	9a	8b	8b
4	Basagran Forte	2.25	L/HA	9a	9a	8b
5	Laddok	4	L/HA	9a	8b	7c
6	Pardner	1.2	L/HA	9a	5e	2h
7	Buctril M	1	L/HA	9a	5e	3g
8	Classic	0.015	KG/HA	9a	8b	7c
9	Select	0.375	L/HA	9a	8b	8b
10	Lontrel	1	L/HA	9a	8b	9a
11	Confront	1.92	L/HA	9a	5e	3g
12	2,4-D Amsol	2.34	L/HA	9a	5e	5e
13	Embutox E	3.5	L/HA	9a	6d	4f
14	Killex	5.5	L/HA	9a	7c	6d
15	Banvel	1.25	L/HA	9a	7c	5e
16	Target	1.5	L/HA	9a	4f	3g
17	Hoegrass	3.52	L/HA	9a	8b	8b
18	Avenge	4.25	L/HA	9a	8b	7c
19	Frontier	1.4	L/HA	9a	8b	8b
20	Excel Super	0.67	L/HA	9a	8b	7c
21	Fusilade II	2	L/HA	9a	8b	8b
22	Venture	1	KG/HA	9a	8b	8b
23	Broadstrike (lontrel)	3.1	L/HA	9a	8b	8b
24	Broadstrike (dual)	2.4	L/HA	9a	8b	7c
25	Reflex	1	L/HA	9a	7c	7c
26	Pronone	20	KG/HA	9a	8b	6d

Table 1. (Cont.) Crop tolerance data for post-emergent herbicide treatments

Trt No.	Treatment Name	Rate	Rate Unit	Treatment Evaluation Interval		
				3-5 DAT	7-14 DAT	21-28 DAT
27	Velpar	8	KG/HA	9a	8b	6d
28	Assert	0.4	L/HA	9a	7c	5e
29	Pursuit	0.42	L/HA	9a	8b	8b
30	Valor (Pursuit Plus)	3.4	L/HA	9a	8b	7c
31	Cobra	0.224	KG/HA	9a	4f	2h
32	Lorox DF	4.5	KG/HA	9a	8b	7c
33	MCPA	1.26	L/HA	9a	8b	8b
34	Tropotox	4.25	L/HA	9a	8b	8b
35	Tropotox Plus	4.25	L/HA	9a	8b	8b
36	Mecoprop	7	L/HA	9a	6d	4f
37	Duel II Magnum	1.75	L/HA	9a	8b	8b
38	Primextra Light	7.7	L/HA	9a	8b	8b
39	Sencor 75 DF	1.13	KG/HA	9a	8b	6d
40	Ally	0.007	KG/HA	9a	7c	3g
41	Ultim	0.1	KG/HA	9a	7c	5e
42	Goal	0.12	L/HA	9a	6d	3g
43	Beacon	0.03	KG/HA	9a	7c	4f
44	Kerb	3.25	KG/HA	9a	8b	7c
45	Peak	0.013	KG/HA	9a	8b	8b
46	Assure	1.5	L/HA	9a	8b	7c
47	Elim	0.06	KG/HA	9a	8b	7c
48	Poast	2.72	L/HA	9a	8b	7c
49	Sinbar	1.25	KG/HA	9a	9a	8b
50	Sinbar	0.9375	KG/HA	9a	8b	8b
51	Sinbar	0.625	KG/HA	9a	8b	6d
52	Sinbar	0.3125	KG/HA	9a	8b	7c
53	Pinnacle	0.008	KG/HA	9a	7c	6d
54	Refine Extra	0.02	KG/HA	9a	8b	7c
55	Achieve	0.25	KG/HA	9a	8b	7c
56	Amber	0.25	KG/HA	9a	8b	8b
57	Spartan	0.015	KG/HA	9a	8b	8b
58	Garlon	6	L/HA	9a	5e	2h

* Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)

References

Anonymous. No pub. date. University of Maine Cooperative Extension. Orono, ME. Pp. 2-3.

Anonymous. 1981. Growing Cranberries. Agriculture Canada. Publication 128 2/E.

Anonymous. 1999. Cranberry Pest Management Guide. Atlantic Agriculture. Factsheet No.ACC 1020.

Anonymous. 1999. CI News. The newsletter of the Cranberry Institute. Wareham, Massachusetts. 9(5):4-6.

Bridges, D.C., and Anderson, R.L. 1992. Crop losses due to weeds in the United States- Bridges, D.C., Ed., Weed Science Soc. Of Amer., Champagne, Ill.

Chaffey, H.L., and Sampson, M.G. 1999. Unpublished.

Clark, W.F., et al. 1993. Massachusetts Cranberry Production. An information guide. Cooperative Extension, University of Massachusetts. 35 p.

Dana, M.N. 1990. Cranberry Management. In Callelta, G.J. and Himelrick,D.G. [eds]. Small Fruit Crop Management. By Prentice - Hall, Inc. NewJersey

Demoranville, I.E. and Devlin, R.M. 1992. Cranberry Weed Control, Cranberry Experiment Station, Cooperative Extension, University of Massachusetts.

Eck, P. 1990. The American Cranberry. Rutgers University Press. New Brunswick. NJ.

Else, M.J., Sandler, H.A. and Schluter, S. 1995. Weed mapping as a component of Integrated Pest Management in cranberry production. *Hort Technol.* 5(4).

Holm, L.G. et al 1977. The World's Worst Weeds, Distribution and Biology. East-West Center, University Press of Hawaii, Honolulu. 609 p.

Jensen, K. 1999. Weed control with herbicides in cranberry production. Nova Scotia Cranberry Management Course '99, Agriculture and Agri-Food Canada.

Johnston, B. Personal Communication.

Lewis, J.C. 1998. What's going on in Cranberry Research. Berry Crops Newsletter, Number 4, September 08, 1998. N.S. Dept. of Agriculture and Marketing.

McCully, K. 1999. Personal Communication.

McCully, K. 1999. Pesticide and fertilizer application equipment. Nova Scotia Cranberry Management Course '99, New Brunswick Department of Agriculture and Rural Development.

Oudemans, P.V., Caruso, F.L. and Stretch, A.W. 1998. Cranberry fruit rot in the northeast: A complex disease. *Plant Disease*. **82**: 1176-1184.

Patten, K.D. and Wang J. 1994. Cranberry yield and fruit quality reduction caused by weed competition. *HortScience*. **29**: 1127-1130.

Pickett, G. 1999. Common weeds in Nova Scotia cranberry production. Nova Scotia Cranberry Management course '99, N.S. Dept. of Agriculture and Marketing.

Roper, T. 1999. Pesticide updates. Cranberry Crop Management Newsletter. University of Wisconsin-Madison, Wisconsin. 13:3-4.

Sampson, M.G. 1999. Pesticide safety practices. Presented at, Nova Scotia Cranberry Management Course '99, Nova Scotia Agricultural College, Department of Environmental Sciences.

Sandler,H.A. and Bewick, T.A. 1998. Weed Management 1998. 1998 Cranberry Chart Book, Management Guide for Massachusetts. University of Massachusetts, Cranberry Experimental Station. Pp. 17-30.

Sears, J.R., Dunn, J. and Harrison, B. 1996. An Illustrated Guide to the Weeds of Cranberry Bogs in Southeastern New England. University of Massachusetts, Dartmouth. 92 p.

Swanton, C.J., Harker, K.N. and Anderson, R.L. 1993. Crop losses due to weeds in Canada. *Weed Technology*. 7: 537-542.

Webster, T. Personal Communication.

Weldon, M. 1999. IPM strategies for weed management : weed mapping. Presented at, Nova Scotia Cranberry Management Course '99, Clean Sweep Cranberry Management, Massachusetts.

Yas, A.M. and Eaton, G.W. 1983. Effect of cotton-grass on the yield components of cranberry. *Scientia Horticulturae*. **18**: 125-129.

Appendix 1. Post-emergent weed control products list.

Use*	Common Name	Trade Name ®	Active Ingredient	Product Rate
post	acifluorfen	Blazer	240 g/L	2.50 L/ha
post	atrazine	Atrex 90	90%	1.65 kg/ha
post	bentazon	Basagran Forte	480 g/L	2.25 L/ha
post	bentazon/atrazine	Laddock + Assist, 2.0 L/ha	(1:1)400 g/L	4.0 L/ha
post	bromoxynil	Pardner	280 g/L	1.2 L/ha
post	bromoxynil/mcpa	Buctril M	280 g/L	1.00 L/ha
post	chlorimuron-ethyl	Classic + Agral 90, 0.2%	25%	0.015 kg/ha
post	clethodim	Select + Amigo, 1.0%	240 g/L	0.375 L/ha
post	clopyralid	Lontrel	200 g/L	1.00 L/ha
post	clopyralid/triclopyr	Confront	270 g/L	1.92 kg/ha
post	2,4-D	2,4-D Amsol	470 g/L	2.34 L/ha
post	2,4-DB	Embutox E	400 g/L	3.50 L/ha
post	2,4-D/dicamba/mecoprop	Killex	320 g/L	5.50 L/ha
post	dicamba	Banvel	480 g/L	1.25 L/ha
post	dicamba /MCPA/MCPP	Target	400 g/L	1.50 L/ha
post, dose	dichlobenil	Casoron	4%	110 kg/ha
post	diclofop-methyl	Hoegrass	284 g/L	3.52 L/ha
post	difenzoquat	Avenge	200 g/L	4.25 L/ha
post	dimethenamid	Frontier	900 g/L	1.40 L/ha
post	fenoxaprop-ethyl	Excel Super	80.5 g/L	0.67 L/ha
post	fluazifop-p-butyl	Fusilade II	125 g/L	2.00 L/ha
post	fluazifop-p-butyl	Venture + Turbocharge, 0.5%	25%	1.00 kg/ha
post	flumetsulam/clopyralid	Broadstrike (lontrel)	923 g/L	3.10 L/ha
post	flumetsulam/metolachlor	Broadstrike (dual)	923 g/L	2.40 L/ha
post	fomesafen	Reflex	240 g/L	1.00 L/ha
post	hexazinone	Pronone	10%	20 kg/ha
post	hexazinone	Velpar	240 g/L	8.00 L/ha
post	imazethapyr	Pursuit	240 g/L	0.42 L/ha
post	isoxaben	Gallery	75%	1.0 kg/ha
post	lactofen	Cobra	23%	0.224 kg/ha
post	linuron	Lorox	50%	4.50 kg/ha
post	mcpa	MCPA	400 g/L	1.26 L/ha
post	mcpb	Tropotox	400 g/L	4.25 L/ha
post	mcpb/mcpa	Tropotox plus	400 g/L	4.25 L/ha
post	mecoprop	Mecoprop	150 g/L	7.00 L/ha
post	metolachlor	Dual II magnum	915 g/L	1.75 L/ha
post	metolachlor/atrazine	Primextra light	500 g/L	7.70 L/ha

Appendix 1 (cont.). Post-emergent weed control products list.

Use*	Common Name	Trade Name ®	Active Ingredient	Product Rate
post	metribuzin	Sencor	75%	1.13 kg/ha
post	metsulfuron-methyl	Ally	60%	0.007 kg/ha
post	nicosulfuron	Accent + Agral 90, 0.2%	75%	0.033 kg/ha
post	nicosulfuron/rimsulfuron	Ultim + Agral 90, 0.2%	25%	0.10 kg/ha
post	oxyfluorfen	Goal	192 g/L	0.63 L/ha
post	primisulfuron-methyl	Beacon + Agral 90, 0.2%	75%	0.030 kg/ha
post	propyzamide	Kerb	50%	3.25 kg/ha
post	prosulfuron	Peak + Agral 90, 0.2%	75%	0.013 kg/ha
post	quizalofop-ethyl	Assure + Canplus 411, 1.0%	96 g/L	1.50 L/ha
post	rimsulfuron	Elim + Agral 90, 0.2%	25%	0.06 kg/ha
post	sethoxydim	Poast + Merge, 2 L/ha	184 g/L	2.72 L/ha
post, dose	terbacil	Sinbar	80%	1.25 kg/ha
post	thifensulfuron methyl	Pinnacle + Agral 90, 0.1%	75%	0.008 kg/ha
post	thifensulfuron-m/tribenuron-m	Refine extra + Agral 90, 0.2%	75%	0.020 kg/ha
post	tralkoxydim	Achieve + Tcharge, 0.5% v/v	250 g/L	0.250 kg?ha
post	triasulfuron	Amber + Agral 90, 0.2% v/v	75%	0.250 kg/ha
post	tribenuron-methyl	Spartan + Agral 90, 0.2% v/v	75%	0.015 kg/ha
post	triclopyr	Garlon	359 g/L	6.00 L/ha

* Use : Post = post-emergent application

Dose = used in a dose response experiment (dose response application rates will consist of the product rate reported in the above table, ¾ rate, ½ rate and ¼ rate)

Appendix 2. Pre-emergence weed control product list

Use*	Common Name	Trade Name ®	Active Ingredient	Product Rate
pre	atrazine	Atrex 90	90%	1.65 kg/ha
pre	dimethenamid	Frontier	900 g/L	1.40 L/ha
pre	ethalfluralin	Edge	60%	1.90 kg/ha
pre	flumetsulam/clopyralid	Broadstrike (lontrel)	923 g/L	3.10 L/ha
pre	flumetsulam/metolachlor	Broadstrike (dual)	923 g/L	2.40 L/ha
pre	hexazinone	Pronone	10%	20 kg/ha
pre	hexazinone	Velpar	240 g/L	8.00 L/ha
pre	imazethapyr	Pursuit	240 g/L	0.42 L/ha
pre	imazathepyr/metribuzin	Conquest	(1:5.4)74%	0.68 kg/ha
pre	imazathepyr/pendimethalin	Valor	(1:14.5)342 g/L	3.4 L/ha
pre	linuron	Lorox	50%	4.50 kg/ha
pre	metobromuron	Patoran	400 g/L	5.63 L/ha
pre	metolachlor	Dual II magnum	915 g/L	1.75 L/ha
pre	metolachlor/atrazine	Primextra light	500 g/L	7.70 L/ha
pre	metribuzin	Sencor	75%	1.13 kg/ha
pre, dose	napropamide	Devrinol	10%	45.0 kg/ha
pre	propyzamide	Kerb	50%	3.25 kg/ha
pre	simazine	Simazine	80%	2.75 kg/ha
pre	trifluralin	Treflan	400 g/L	2.75 L/ha

* Use : Pre = pre-emergence application
Dose = used in a dose response experiment (dose response application rates will consist of the product rate reported in the above table, ¾ rate, ½ rate and ¼ rate)

EVALUATION OF WEED CONTROL METHODS FOR USE ON GILBERT ISLAND PASTURES

ÉVALUATION DE MÉTHODES DE LUTTE CONTRE LES MAUVAISES HERBES POUR LES PÂTURAGES DE L'ÎLE GILBERT

K.V. McCully[1], D. Ward[2] and/et W. Brown[3]

Partner/ Partenaire: Sussex and Studholm Agricultural Society

Abstract. A trial to evaluate Lontrel 360, MCPA amine 500, Roundup (wiper), and clipping for weed control and crop tolerance within a pasture was conducted. Visual ratings on weed control and grass injury were collected throughout the season. Botanical compositions were also determined following sampling at two different dates. Results indicated that Canada thistle was the most predominant weed and that all treatments provided significantly higher visual control than the untreated check. Roundup (wiper) (99%) and Lontrel (94%) were the two most effective treatments. Analysis of botanical composition data (% grass, % clover, % weeds) indicated that no significant differences between the treatments or untreated control existed. Trends however, indicated that Lontrel resulted in the highest percentage grass, and lowest percentage weeds within the collected samples. Clover was killed from the Lontrel treatment, however. Additional ratings and botanical compositions should be collected next season to evaluate long-term effects of the treatments.

Résumé : Un essai dans un pâturage a permis d'évaluer l'efficacité du Lontrel 360, du MCPA amine 500, du Roundup (par humectation) et de la tonte sur les mauvaises herbes, et de déterminer la tolérance des cultures à ces traitements. On a évalué visuellement le taux de destruction des mauvaises herbes et les dommages à la culture durant toute la saison. Des échantillonnages ont été faits à deux dates différentes pour déterminer la composition botanique du pâturage. Les résultats indiquent que la mauvaise herbe dominante était le chardon des champs, que tous les traitements ont été efficaces, et que beaucoup plus de mauvaises herbes avaient été détruites dans les parcelles traitées que dans la parcelle témoin non traitée. Le Roundup appliqué par humectation (99 %) et le Lontrel (94 %) ont été les deux traitements les plus efficaces. Les résultats de l'analyse botanique, qui permet de déterminer la proportion de graminées, de trèfle et de mauvaises herbes, ont indiqué qu'il n'existait pas d'écart important entre les parcelles traitées et celle non traitée. Dans les échantillons analysés, on constate cependant que la proportion de graminées était plus grande dans les parcelles traitées avec le Lontrel, et que la proportion de mauvaises herbes était plus faible. Toutefois, le trèfle avait été détruit par le traitement au Lontrel. Des évaluations et des analyses botaniques additionnelles doivent être faites la saison prochaine pour déterminer les effets des traitements à long terme.

Introduction

In 1996, a Steering Committee was created to investigate and implement a management plan for the community pasture on Gilbert Island. The committee consisted of representatives from the New Brunswick Department of Agriculture and Rural Development, the New Brunswick Department of Natural Resources and Energy, the Canadian Wildlife Service, and the Sussex and Studholm Agricultural Society. A consultant was hired to assess the Island and develop a management plan. The recommended plan involved the fencing of the more

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

2 Land Resource Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction des ressources des terres agricoles, MAARNB, Fredericton, NB E3B 5H1

3 Sussex Regional Office, Southern Region, NBDARD, Sussex, NB / Bureau régional de Sussex, Région du Sud, MAARNB, Sussex, NB

sensitive areas of the Island to exclude cattle, and the implementation of a rotational grazing system on the remaining land which would support the same number of cattle over less acreage.

A fertility trial was conducted in 1998 as a means to improve the pasture productivity. The results indicated that the pasture productivity could not be feasibly improved through the addition of commercial fertilizers without increasing the soil pH of the pasture. The large amount of agricultural lime required (> 2.5 ton/acre) and difficulty accessing the Island made this unfeasible. In 1999 the focus shifted to weed management as the stakeholders decided to improve the forage stand by reducing weed pressure. It was felt that if weeds could be properly managed that rotational grazing would be more successful and pasture productivity would increase.

A successful weed management strategy for Gilbert Island must take into consideration the late accessibility to the Island due to high spring water levels, the difficulty in transporting machinery to the Island, and any grazing restrictions for herbicides if used.

A trial was therefore established to evaluate the effectiveness and feasibility of weed management options for use on an island pasture where rotational grazing was being practiced.

Treatments chosen included Lontrel 360, MCPA amine 500, Roundup wiping, clipping, and an untreated control. Lontrel was chosen because of its known effectiveness for controlling Canada thistle and because cattle are permitted to graze immediately following application. MCPA amine was chosen as a cheap alternative to Lontrel which has a short grazing restriction period of 7 days following application. Roundup selectively applied through a wiper was chosen because it is known to provide excellent weed control, and also because it has a short grazing restriction period of 3-5 days. Clipping was chosen as a non-chemical method of weed control.

Materials and Methods

The trial was established on Gilbert Island, located in the Saint John River approximately 10 km east of Oromocto. The trial was a randomized complete block design with four replicates. In order to take into account rotational grazing from one side of the island to the other as well as differences in weed, grass, and clover species distribution and density, replicates were scattered across the island. Two of the replicates were located at different locations on the south side of the island, and two replicates at different locations on the north side of the. Plot size was 10 x 10 M.

Cattle were transported to the island by barge on May 20 and 21st, shortly after the electric fence was repaired to divide the island into two paddocks for rotational grazing purposes. Cattle were moved from one side of the island to the other approximately every 10 to 14 days.

Treatments included MCPA amine 500 applied at 2 L/ha, Lontrel 360 EC applied at 0.56 L/ha, Roundup applied with a hockey stick sideswipe wiper at a 33% mix, and clipping with hand clippers to simulate a mowing. MCPA and Lontrel were applied post emergent on June 1, 1999 with a CO_2 hand held sprayer. Herbicides were applied in a water volume of 170 L/ha at 207 Kpa pressure. Thistles at time of spraying were predominantly at the rosette stage, with a few up to 20 cm high. Grasses on the south side of the island (rep 1 & 2) were 7.5 to 17.5 cm high, and on the north (rep 3 & 4) many had headed out.

Thistles were too short for wiping or clipping at the June 1st date and were therefore not treated until July 16, 1999. Thistles on July 16 were between 10 cm and 30 cm high. A second clipping and wiping was also done on September 12, 1999, but few thistles were present.

Cages (3 ft x 3 ft x 1 ft) were randomly placed within each plot on replicates 1, 2, and 3 in order to collect undisturbed samples for botanical and nutritional compositions. Samples were categorized into weeds, clovers, and grasses, and samples were analyzed for % DM, % protein, % TDN, and % ADF. Samples were collected on June 25 and on August 23, 1999. Percent DM, % protein, % TDN, and % ADF results were available for June 25 only, and are not reported.

Visual evaluations on grass injury and thistle control were collected July 16 and September 13. Visual ratings were collected on a scale of 0-100% where 0 represented no crop injury or weed control, and 100 represented complete kill. Data was analyzed through an analysis of variance, and means separated by the LSD test (P=0.05).

Results and Discussion

Grass Injury. Grasses present on the island were mostly native grasses (ie bluegrasses, fescues, bentgrasses). The only treatment to visually result in grass injury at anytime throughout the season was from the Roundup wiping treatment (Table 1). Roundup is a non-selective herbicide that kills most all plants that it comes in contact with. Roundup when applied through a wiper is applied to vegetation growing above the desired crop, in order to avoid contact and subsequent crop injury. In this trial there were a number of small Canada thistle

Table 1. Visual evaluations and botanical composition data

Treatments	Rate	% Grass injury (0-100)	% Canada thistle control 0-100		Pasture yield T/ha	Botanical compositions			Pasture yield T/ha	Botanical compositions		
						% Grass	% Clover	% Weeds		% Grass	% Clover	% Weeds
		July 16	July 16	Sept 13	June 25	June 25	June 25	June 25	Aug 23	Aug 23	Aug 23	Aug 23
Untreated	-	0	0	0 c*	19.8	91.7	.8	7.5	13.6	77	6	17
Clipping	-	0	-	83 ab	19.0	81.0	11	8.0	22.1	91.5	2.2	6.3
Roundup (wiping)	33% mix	15%	-	99 a	16.8	81.0	9	10.0	15.5	88.1	1.1	10.8
MCPA amine 500	2.0 L/ha	0	50	66 b	21.1	73.8	0	26.1	18.1	92.9	1.8	5.3
Lontrel 360	0.56 L/ha	0	68	94 ab	20.5	92.5	0	7.5	20.5	97.6	0	2.4
LSD$_{(2)}$ (.05)			7.9	29	N.S.$_{(1)}$	N.S.	8.1	N.S.	N.S.	N.S.	N.S.	N.S.

* Means followed by the same letter within each column are not significantly different from each other (LSD 5%)

(1) Not significant

(2) Least significant difference

rosettes close to the ground and some grass could not be avoided when wiping. As a result a few grass patches around the thistle were killed. By wiping at a later date when thistles would be taller this problem could be avoided, however. The remaining treatments caused no injury symptoms on the grass species anytime during the season.

Weed Control. Various and numerous weeds were found scattered across the island, but the two weeds avoided most frequently by cattle were Canada thistle and milkweed. For this trial however, only Canada thistle was targeted for control as milkweed was not found consistently or uniformly across the trial areas.

Canada thistle control. At the July 16 rating only MCPA and Lontrel treatments were rated, as the clipping and wiping treatments had just been applied earlier in the day. Results indicated that MCPA resulted in 50% suppression and Lontrel 68% suppression (Table 1). In both cases Canada thistle was still present, but was short and small.

At the September 13 rating all treatments provided significantly higher Canada thistle control than the untreated check (Table 1). The best overall treatment resulted from the Roundup wiping treatment (99%) followed by Lontrel (94%), clipping (83%), and MCPA (66%). It therefore appears that either Roundup applied through a wiper, Lontrel, or clipping could be used effectively to reduce Canada thistle populations.

Botanical Compositions. It is difficult to make any definitive statements about total pasture yield, % grass, % clover, or % weeds from the June 25 sampling as the Roundup wiping and clipping treatments had not yet been applied (applied July 16). Variability across the replicates for all the treatments existed and as a result differences were not significant when looking at total pasture yield, % grass, and % weeds (Table 1). Significant differences in % clover existed surprisingly between the three treatments which had not yet been applied, thereby indicating the variability between replicates (Table 1). No clover was present in the MCPA and Lontrel plots. This was expected however, as clover is known to be somewhat sensitive to MCPA and very sensitive to Lontrel.

Sampling was also done on August 23, which unlike the June 25 sampling, was collected after all the treatments had been applied. Results indicated that there were no significant differences in overall pasture yields, % grass, % clover, or % weeds between treatments or the untreated control (Table 1).

Although differences were not significant some trends were evident. The two broadcast herbicide treatments tended to be the most effective. Lontrel provided the highest % grass (97.6%) and lowest % weed population (2.4%) in the collected samples (Table 1). The disadvantage however, was that it killed all the clover. The next best treatment was MCPA with 92.9% grass, 5.3% weeds, and

1.8 % clover in plots. Clipping provided the next best results with 91.5% grass, 6.3% weeds, and 2.2 % clover. Roundup wiping resulted in 88.1% grass, 10.8% weeds and 1.1 % clover. The lower percent grass was likely the result of grass injury from trying to wipe Canada thistle seedlings, which were growing low within the grasses. Although Roundup wiping resulted in the lowest grass % of the treatments it was still better than the 77% grass and 17% weeds in the untreated plots.

In order to determine the true effectiveness of the tested treatments it will be necessary to further evaluate the treatments next season to determine their long-term effectiveness. Differences in botanical compositions between treatments will likely be easier to detect the year following application.

Conclusions

Overall, final pasture yields and botanical composition differences between treatments were not significantly different from each other. There were however, trends and advantages and disadvantages of treatments that were evident.

The best overall treatment in terms of providing Canada thistle control, with excellent grass tolerance was Lontrel. The disadvantages of this treatment however, is that it kills out the desired clover and its expense (approx. $ 32.00/acre). MCPA was not very effective on Canada thistle (66%) but % grass was high (92.9%) in the botanical composition, and overall % weeds was second best to only Lontrel. Advantages of MCPA is it did not kill out all the clovers and it is a cheap herbicide (approx. $ 5.00/acre).

Roundup wiping provided the highest level of Canada thistle control but provided the highest grass injury levels as a result of wiping too low. If grasses can be grazed enough to keep the grasses down below the thistle plants, wiping could be a very effective control method. If timely rotational grazing is not practiced, and grasses are permitted to grow tall as was the case this season, Roundup wiping would be risky. The advantage of this method of control is that a 4-wheeler (ATC) could be used to pull a wiper and could be transported to the Island much easier than a tractor and sprayer.

Clipping provided 83% control of Canada thistle at the September 13 date, and botanical compositions indicated that % grass (91.5%) increased as compared to the untreated control (77%). The percentage of weeds (6.3%) was less than observed in the untreated control (17%). If chemical control is undesirable from an environmental standpoint, clipping may be a viable alternative.

Overall, it is difficult to recommend one treatment over another, as statistically no significant differences existed between treatments when evaluating botanical compositions. Additional ratings and botanical separations should also be collected next year to evaluate the long-term effect of the treatments.

Acknowledgements

Special thanks are extended to Anthony Smith and Mike Price, NBDARD for their invaluable assistance with this trial.

POTATOES / POMMES DE TERRE

OPTIMIZATION OF A PCR METHOD FOR FINGERPRINTING POTATO VARIETIES

OPTIMISATION D'UNE MÉTHODE PCR POUR LA CARTOGRAPHIE DE VARIÉTÉS DE POMMES DE TERRE

Xiu-Qing Li[1], Shirlyn Coleman[2], Birt Stevens[1] and/et Muhammad Haroon[1]

Partner / Partenaire : Potato Research Centre, Agriculture and Agri-Food Canada / Centre de recherche sur la pomme de terre, Agriculture et Agroalimentaire Canada)

Abstract: An optimized protocol for fingerprinting potato varieties with SSR-PCR (PCR of the microsatellite DNA region) for the *patatin* gene was developed using appropriate reaction conditions (7 °C lower than Tm temperature). The optimized method can unambiguously distinguish the three potato varieties Shepody, Russet Burbank, and Niska tested whereas the widely used unoptimized method could not.

Résumé : On a élaboré un protocole optimal pour la cartographie de variétés de pommes de terre avec la méthode SSR-PCR (PCR de la région DNA microsatellite) pour le gène *patatin*, en appliquant les conditions favorables à la réaction (7 °C de moins que la température de fusion). Cette méthode optimale permet de distinguer nettement les trois variétés de pomme de terre testées (Shepody, Russet Burbank et Niska), tandis que la méthode populaire non optimale ne permet pas cette distinction.

Introduction

Correct identification and tracking of material entering and leaving a repository such as the Canadian Potato Variety Repository at the Plant Propagation Centre is crucial. Many potato varieties are morphologically similar. In addition, the ability to use morphological traits to distinguish varieties often requires that the material is grown under specific growing conditions and observed at a precise time of development. Consequently morphology based tests for identifying differences between varieties can not always be relied on to positively distinguish between varieties. A method that would provide a reliable, reproducible method of identifying varieties and which could be used as a template to compare future material produced from the original source would provide a very useful tracking tool.

Abbreviations: DNA: deoxyribonucleic acid; Tm: melting temperature of the DNA hybrid molecules; PCR: polymerase chain reaction of DNA; RAPD: random amplified polymorphic DNA; RFLP: restriction fragment length polymorphism; AFLP: and amplified fragment length polymorphism; SSR: simple sequence repeat also known as microsatellite.

---

[1] Potato Research Centre, Agriculture and Agri-Food Canada, 850 Lincoln Road, P.O. Box 20280, Fredericton, NB E3B 4Z7 / Centre de recherche sur la pomme de terre, Agriculture et Agroalimentaire Canada, 850, chemin Lincoln, C.P. 20280, Fredericton, NB E3B 4Z7

[2] Plant Propagation Centre, NBDARD, Fredericton, NB E3B 5H1 / Centre de propagation des végétaux, MAARNB, Fredericton, NB E3B 5H1

DNA is the genetic makeup of the varieties and is stable regardless of the growing stages and conditions of a plant. It can be extracted from any part of the plants such as from leaves, shoots, tubers, or roots. DNA fingerprinting provides the most reliable method for distinguishing between varieties. However, DNA fingerprints cannot usually be used to authenticate a variety but can be used to demonstrate with high accuracy whether different samples are from the same variety.

There are various types of DNA fingerprints such as RAPD, SSR (also called microsatellite), RFLP, and AFLP. RAPD method is the simplest one but least reproducible. RFLP and AFLP are laborious and require manipulation of radioactive isotopes. SSR markers are simple and one of the most reproducible methods used for fingerprinting crop varieties (Kawchuck *et al.*, 1996; Kulcsar. 1996; Provan *et al.*, 1996; Schneider et al., 1997). Therefore, SSR is the method of choice for normal fingerprinting (Morgante *et al.*, 1993; Saghai Maroof *et al.*, 1994).

To detect the microsatellite DNA variations using PCR method, pairs of primers flanking microsatellite DNA regions are required. The DNA fragments can be amplified to form millions of copies and therefore the fragment can be seen in an electrophoresis gel. The size polymorphisms of DNA fragments can be directly compared after photography of the electrophoresis gel. Each pair of primers can amplify one to a few DNA fragments. In order to distinguish many potato varieties, many pairs of primers would be required. The ability of primers to detect polymorphisms is usually positively correlated with the number of DNA fragments of the PCR products. Any improvement of the ability to detect more DNA regions or fragments could potentially improve the fingerprinting efficiency.

In the present report, we describe an optimization of a SSR-PCR method to increase the usefulness of DNA primers flanking the microsatellite of patatin genes that encode the major storage protein of potatoes.

Materials and Methods

A pair of primers flanking the $(AATT)_5$ microsatellite region of the potato patatin pseudo-gene initially described by Veilleux et al. (1995) was used in the present study. The primers have the following sequences: 5'-CAA CCA ACA AGG TAA ATG GTA CC-3' (Tm=61°C) and 5'-TGG TCT GGT GCA TTA GAA AAA A-3' (Tm = 57°C).

There varieties, Shepody, Russet Burbank, and Niska of the potato (*Solanum tuberosum* L.) were used. Disease-free tubers were surface sterilized by 1% sodium hypochlorite solution for 10 minutes, followed by three rinses with autoclaved distilled water. Total DNA was extracted according to Doyle and Doyle (1990) method and dissolved in buffer TE (Sambrook, 1989).

PCR amplification using the primers was carried out in a total reaction volume of 20 μl containing 1X PCR-reaction buffer (50 mM KCl, 10 mM Tris of pH 8.3, and 2 mM $MgCl_2$), 10 ng template DNA, 0.5 unit of AmpliTaq Gold DNA polymerase (Perkin Elmer), 0.4 mM of each of dATP, dCTP, dGTP, and dTTPs, and 0.5 μM of each primer. All the amplifications were conducted using the GeneAmp PCR System 9700 of Perkin Elmer Inc.

Two PCR reaction conditions were compared: one was with the most commonly used annealing temperature of 55°C for the patatin gene primers, and the other with a lower annealing temperature of 50°C. The general reaction parameters were: 1) 94°C , 10 minutes; 2) 55°C or 50°C , 3 minutes; 3) 30 cycles of 1 minutes at 94°C, 1.5 minutes at 55°C or 50°C, and 1.5 minutes at 72°C, 4) seven minutes for 72°C.

After PCR amplifications, the amplified products were resolved on 1.4% agarose gels of 1X TBE (Sambrook, 1989) containing ethidium bromide (0.5 μg/L), and photographed under ultraviolet light by a digital imaging system.

Results and Discussion

The patterns of PCR products after PCR at 55°C or 50°C were shown in Figure 1. At a 55°C annealing temperature (Fig. 1A) mainly one DNA fragment, as expected size, of about 0.39 kb (Band b in Fig. 1A) was detected for all three varieties (Niska, Shepody, and Russet Burbank). Two additional faint bands of 0.43 kb (Band a, Fig. 1A) and 0.31 kb in the lane containing Russet Burbank and one faint band of 0.43 kb in Niska were also sometimes visible on agarose gel. These faint bands were not very reproducible and were quite ambiguous, especially when using different thermal cyclers. These faint bands were only visible when a large amount of DNA was loaded during electrophoresis, as in the case of Figure 1A. Therefore the SSRs detected at 55°C were not very informative, and the varieties could not be clearly distinguished from each other.

At a 50°C annealing temperature (Figure 1B), Niska amplified two fragments of 0.43 kb (Band a, Fig. 1A) and 0.39 kb (Band b, Fig. 1B), Shepody amplified one fragment of 0.39 kb, and Russet Burbank amplified three fragments of 0.43 kb, 0.39 kb, and 0.31 kb (Band c, Fig. 1B). Therefore, all the three varieties could be distinguished from each other using the same pair of SSR primers. The results clearly indicate that by using the right temperature for the primer-template annealing stage, patatin-SSR primers dramatically increased their ability in discriminating between potato varieties.

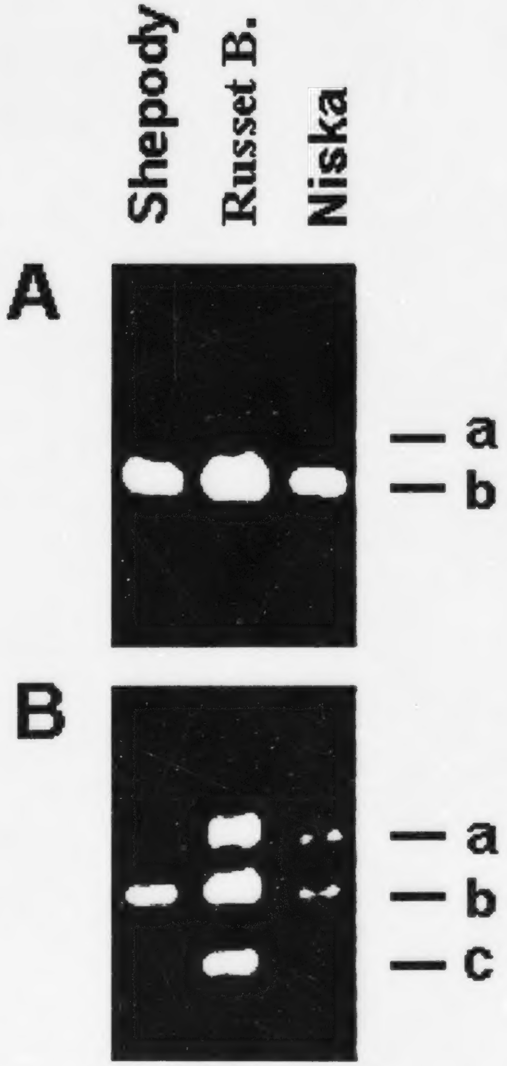

Shepody
Russet B.
Niska
A
B
a
b
a
b
c

Fig. 1. DNA fingerprints for distinguishing potato varieties. A: PCR products from commonly used protocol; B: PCR with improved protocol. The DNA fragments were from the microsatellite region of *patatin* genes.

The increased ability to discriminate between potato varieties in this report can be explained by the detection of more loci or more alleles in addition to the perfect matched region from where the primers were designed. Patatin genes have many partially homologous copies (Pikaard *et al.*,1986; Twell *et al.*, 1988) and therefore are complex, especially in tetraploid potatoes. By appropriately lowering the annealing temperature, the imperfectly matched copies can also be amplified.

Most people either use the Tm temperature as the annealing temperature in the SSR-PCR reactions or use a slightly lower temperature (Kawchuck *et al.*, 1996; Provan *et al.*, 1996; Schneider *et al.*, 1997). An annealing temperature of 50°C (several degrees lower than the Tm of most primers) was used for SSR analysis in maize (Senior *et al.*, 1993) but no other temperature was used for comparison. Veilleux *et al.* (1995) and Schneider and Douches (1997) used the same primers of pseudo-patatin gene for studying DNA polymorphism and for fingerprinting potato cultivars. However, they used an annealing temperature of 55°C. Therefore, to our knowledge, the present report is the first report on the effect of dramatically lowering (7 degree below Tm temperature) the annealing temperature.

In summary, appropriately reducing the annealing temperature can dramatically improve the polymorphism detection ability of the patatin SSR primers. From being able to distinguish only one variety at standard conditions, the same primers can unambiguously distinguish all three varieties at the optimized conditions with very reproducible results. This increased ability in SSR polymorphism detection should improve the applications of the SSR primers in fingerprinting New Brunswick potato varieties.

References

Doyle, J.J. and J.L. Doyle. 1990. Isolation of plant DNA from fresh tissue. *Focus* **12:** 13-15.

Kawchuck, L.M., D.R. Lynch, J. Thomas, B. Penner, D. Sillito and F. Kulcsar. 1996. Characterization of *Solanum tuberosum* simple sequence repeats and application ot potato cultivar identification. *American Potato Journal* **73:** 325-335.

Kulcsar. 1996. Characterization of *Solanum tuberosum* simple sequence repeats and application of potato cultivar identification. *American Potato Journal* **73:**325-335.

Morgante, M. and A.M. Olivieri. 1993. PCR-amplified microsatellites as markers in plant genetics. The Plant Journal **3:** 175-182.

Pikaard, C.S., G.A. Mignery, D.P. Ma, V.J. Stark and W.D. Park. 1986. Sequence of two apparent pseudogenes of the major potato tuber protein, patatin. *Nucleic Acids Research* **14**: 5564 - 5566.

Provan J., W. Powell and R. Waugh. 1996. Microsatellite analysis of relationships within cultivated potato (*Solanum tuberosum*). *Theoretical and Applied Genetics* **92:** 1078-1084.

Saghai Maroof, M.A., R.M. Biyashev, G.P. Yang, Q. Zhang and R.W. Allard. 1994. Extraordinarily polymorphic microsatellite DNA in barley: Species diversity, chromosomal locations, and population dynamics. *Proceedings of National Academy of Science, USA* **91:** 5466-5470.

Sambrook, J., E.F. Fritsch and T. Maniatis. 1989. Molecular cloning: A laboratory manual 2nd edition. NY: Cold Spring Harbor Laboratory Press.

Schneider, K. and D.S. Douches. 1997. Assessment of PCR-based simple sequence repeats to fingerprint North American potato cultivars. *American Potato Journal* **74:** 149-160.

Senior, M.L. and M. Heun. 1993. Mapping maize microsatellites and polymerase chain reaction confirmation of the targeted repeats using a CT primer. *Genome* **36**: 884-889.

Twell, D. and G. Ooms. 1988. Structural diversity of the patatin gene family in potato cv. Desiree. *Molecular and General Genetics* **212:** 325 - 336.

Veilleux, R.E., L.Y. Shen and M.M. Paz. 1995. Analysis of the genetic composition of anther-derived potato by randomly amplified polymorphic DNA and simple sequence repeats. *Genome* **38:** 1153-1162.

TESTING THE EFFECTIVENESS OF BIOPRODUCT XL AND XH AND PRODUCT AG ON GROWTH AND YIELD OF POTATO

ESSAI DES BIOPRODUITS XL ET XH ET DU PRODUIT AG SUR LA CROISSANCE ET LE RENDEMENT DES POMMES DE TERRE

Loretta Mikitzel[1]

Partner / Partenaire: BioAtlantech / Bios Agriculture

Abstract: The effect of three new plant growth regulating compounds (Bioproduct XH, Bioproduct XL and Product AG) on Russet Burbank and Shepody plant growth and tuber yield was studied during the 1999 growing season. The Bioproducts were sprayed and Product AG dusted on seed tubers the day before planting. Bioproduct XL at one-quarter strength increased tuber yields of Shepody and Russet Burbank. Performance of plants treated with quarter-, half- or full-strength Bioproduct XH was not different from that of the control. Shepody appeared to be more responsive than Russet Burbank. Dusting Product AG on seed tubers at the recommended rate was toxic to the potato tubers and inhibited emergence, retarded plant growth and decreased tuber yields. Product AG was also applied to the foliage of Russet Burbank and Shepody plants at tuber hooking stage and hooking stage plus 19 days. No significant effects upon tuber yield were found with either foliar treatment or cultivar tested. The warm weather experienced during the 1999 growing season may have influenced the outcome of this trial. Additional field trials are needed to fully explore the potential and usefulness of these products.

Résumé : Un essai réalisé durant la campagne agricole 1999 a permis de vérifier l'effet de trois composés de régulation de la croissance des végétaux (bioproduit XH, bioproduit XL et produit AG) sur la croissance et le rendement de tubercules des variétés Russet Burbank et Shepody. Les bioproduits ont été pulvérisés et le produit AG a été saupoudré sur les semences un jour avant la plantation. Le bioproduit XL, utilisé au quart de la concentration intégrale, a augmenté le rendement des tubercules des variétés Shepody et Russet Burbank. Le rendement des plants traités avec le bioproduit XH, utilisé au quart, à la moitié ou à la totalité de la concentration intégrale, n'a pas différé de celui des plants témoins. Shepody semble avoir réagit davantage que Russet Burbank. Quant au produit AG saupoudré sur les semences à la dose recommandée, il a été toxique pour les tubercules et a empêché la levée, retardé la croissance des plants et diminué les rendements de tubercules. Le produit AG a aussi été appliqué sur le feuillage des plants de Russet Burbank et de Shepody au stade du crochet des tubercules et 19 jours après ce stade. On n'a pas observé d'effet notable sur le rendement des tubercules à la suite du traitement foliaire ou en fonction des cultivars soumis aux essais. Le temps chaud enregistré durant la saison de croissance 1999 peut avoir influé sur les résultats de l'essai. D'autres essais en pleine terre sont nécessaires pour vérifier le potentiel et l'utilité de ces produits.

Introduction

The primary potato cultivars grown in New Brunswick are used for processing into French fries. Processors demand, and growers benefit from, high yields of large-sized tubers. Russet Burbank, the mainstay of the industry, is a late-maturing cultivar requiring about 140 days to reach full maturity and yield potential. In New Brunswick, the short growing season limits tuber yield. Shepody, the second most popular cultivar, tends to emerge erratically with few stems. To achieve maximum yield, emergence and stem numbers must be improved.

---

[1] Potato and Horticulture Branch, NBDARD, Wicklow, NB E7L 3S4 / Direction de la pomme de terre et horticulture, MAARNB, Wicklow, NB E7L 3S4

The above mentioned characteristics of Russet Burbank and Shepody present growers with production challenges. Environmentally-conscious potato management techniques are needed to improve tuber yield and quality. The present study focused on the application of three new plant growth regulating compounds to the potato tuber or plant aimed at enhancing plant emergence and increasing final yield.

The objectives of this project are:

1. Determine the products' ability to stimulate sprout emergence early in the growing season.

2. Determine the products' ability to increase total tuber and marketable yields.

3. Determine the optimal concentration of the products.

4. To assess the application of Product AG as a seed treatment compared to foliar application.

Materials and Methods

Whole single-drop tubers and 58-70 g seedpieces of certified E3 Russet Burbank and Shepody were used. The tubers and freshly-cut pieces were sprayed with full-, half- and quarter-strength Bioproducts XL and XH until all surfaces were wetted then air-dried. Distilled water was used for Bioproduct dilution and treating control propagules. Product AG applied as a seed piece treatment was dusted on the tubers at a rate of 0.56 kg/ha.

Field plots were 7.6 m long with Russet Burbank propagules planted at a with-in row spacing of 40 cm and Shepody at 30 cm. Fertility and cultural practices were standard for the commercial production of a processing potato crop. The experiment was a randomized complete block design with 4 replicates. Each cultivar was tested separately.

Russet Burbank and Shepody plants that received the foliar Product AG treatment were derived from untreated seedpieces and planted as mentioned above. Product AG (0.35 kg/ha) was applied to the foliage at the hooking stage (Product AG I) and again 19 days later (Product AG II) using 224.6 L water /ha and 1 ml/L non-ionic surfactant. Table 1 shows the timeline of experimental parameters and data collection.

Table 1. Field trial management and data collection dates

Activity	Date
Cut seed tubers	May 31, 1999
Seed treatment	May 31, 1999
Planting	June 1, 1999
Emergence monitoring	June 14-26, 1999
Stem counts	June 28-29, 1999
Canopy measurement	July 5-7, 1999
Product AG I application	July 9, 1999
Product AG II application	July 28, 1999
Topkill date	September 15, 1999
Harvest date	October 12, 1999

During the growing season, plant emergence, average stem number and canopy volume were monitored. Harvested tubers were graded into <5 cm dia.; 5 cm dia.-283 g; > 283 g and cull categories. Average tuber weight, average tuber number per hill and marketable yield were calculated. Canopy volume was calculated by the equation Volume $=(4/3)(\pi)(hr^2)$ where h = plant height, $\pi = 3.14$ and r = radius of the plant at ground level. Data analysis was performed using the GLM of SAS.

Results and Discussion

Seed Treatments. Where seed type and treatment are significant, both will be discussed. Otherwise only main effects of seed type or treatment will be presented where appropriate.

1. Emergence. Seed type and treatment had significant ($P<0.01$) effects on emergence of Russet Burbank through 23 days after planting then differences disappeared (Fig. 1). Applying Bioproducts to the whole (Fig.1A) or cut (Fig. 1B) seed sped emergence slightly while Product AG delayed emergence. Whole seed initially emerged more rapidly than cut seed.

Significant treatment and seed type effects ($P<0.01$) were found for emergence of Shepody until 55DAP (Fig.2). As with Russet Burbank, whole seed emerged faster than cut seed. Compared with the control, all concentrations of both Bioproducts enhanced emergence early in the season when applied to cut seed (Fig. 2A). When applied to whole seed, only Bioproduct XL 25 had a positive effect on emergence by 21 days after planting (Fig.2B). Product AG applied to Shepody cut and whole seed significantly inhibited emergence.

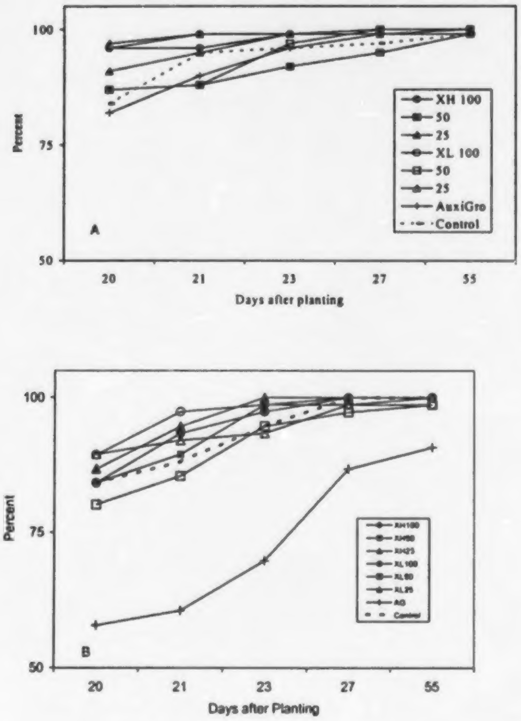


Fig.1. Emergence of Russet Burbank plants from whole (A) and cut (B) seed treated with Bioproducts and Product AG.

2. Stem and tuber numbers. Treating Russet Burbank whole or cut seed with Bioproduct XL or XH had no effect on the number of stems produced, which averaged 3.6 stems per plant (Table 2). Seed type however, had a significant (P<0.01) effect on stem numbers. Whole seed produced fewer stems (3.25 stems/plant) than did cut seed (4.0 stems/plant). For all seed treatments and both AG reduced the yield of 5 cm-283 g tubers, the Bioproducts did not. Yield of desirable large tubers (>283 g) was highest for Bioproduct XL at one-quarter strength, significantly higher than that from seed treated with half-strength seed types, Russet Burbank tuber number per stem and per plant were similar, averaging 2.8 and 10.1, respectively.

Only the Product AG seed treatment affected stem number of Shepody plants (Table 2). It reduced stem number of plants from whole seed from an average of 4.0 stems/plant to only 2.25 stems per plant. Plants from Product AG treated cut seed produced an average of 2.5 stems/plant, a reduction of 0.55 stems/plant compared with the control. Tuber number per stem, 1.9 on average, was similar for all Shepody plants. Tuber number per plant however was reduced by the

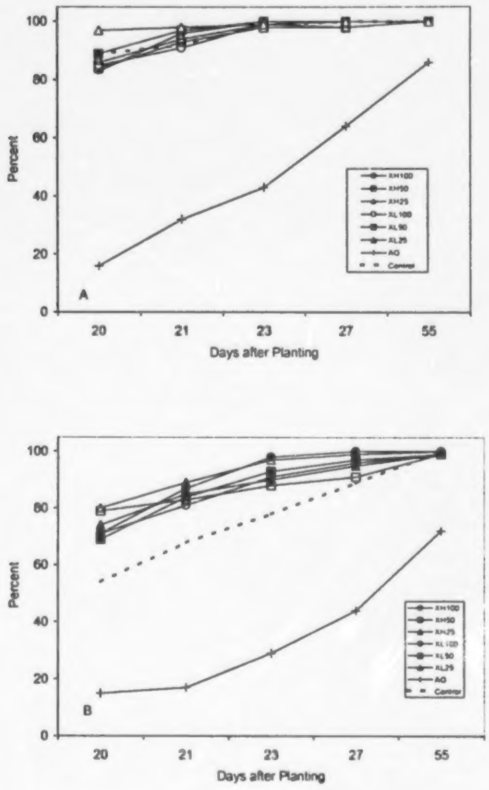


Fig.2. Emergence of Shepody plants from whole seed (A) and cut seed (B) treated with Bioproducts and Product AG.

Product AG treatment. Plants from Product AG treated seed produced only 4.8 tubers/plant compared with an average of 6.8 tubers/plant for the other treatments (Table 2).

3. Canopy volume. For both Shepody and Russet Burbank, seed type did not affect canopy volume when measured 34-36 days after planting. Table 3 shows the main effect of seed treatment, averaged over seed type, for both cultivars. Canopy volume of the Russet Burbank plants treated with the Bioproducts was similar to that of the control plants. Plants from the Product AG treated seed were significantly smaller than any other Russet Burbank plants.

Table 2. Average stem and tuber numbers of Russet Burbank and Shepody plants after treatment with Bioproducts XH and XL and Product AG

Treatment	Russet Burbank			Shepody		
	Cut seed	Whole seed	Tubers/ Plant	Cut seed	Whole seed	Tubers/ Plant
	Stem #/plant			*Stem #/plant*		
XH 100	4.1a*	3.3a	10.4a	4.4a	3.0a	7.0a
50	4.1a	3.4a	9.9a	4.1a	3.1a	6.8a
25	4.0a	3.2a	10.4a	4.0a	3.1a	7.2a
XL 100	4.1a	3.2a	10.8a	3.8a	3.1a	6.5a
50	4.1a	3.2a	9.7a	4.0a	3.2a	6.5a
25	3.9a	3.2a	10.4a	4.0a	3.2a	7.2a
Product AG	3.7a	3.2a	9.1a	2.25b	2.5b	4.8b
Control	4.0a	3.3a	10.4a	3.8a	3.2a	6.6a

* values within a column followed by the same letter are not significantly differently at P=0.05.

Table 3. Canopy volume of Russet Burbank and Shepody after treatment with Bioproducts

Treatment	Russet Burbank	Shepody
	Litres	*Litres*
XH 100	65.02a*	58.44ab
50	61.02a	58.30ab
25	65.09a	60.64ab
XL 100	64.27a	57.34ab
50	61.38a	57.53ab
25	66.83a	66.73a
Product AG	49.14b	27.74c
Control	60.63a	56.09b

* values within a column followed by the same letter are not significantly differently at P=0.05.

Bioproduct XL applied at one-quarter strength to Shepody seed stimulated plant growth and these plants were the largest. The other Bioproduct treatments were not different from the control. As with Russet Burbank, Product AG appeared to stunt the growth of Shepody, resulting in the smallest plants.

4. Tuber yield. Total yield of Russet Burbank tubers was similar for all Bioproduct treatments (Fig.3). Yield from Product AG treated seed was reduced compared with the control. The treatments which significantly affected marketable yield were Bioproduct XL at one-quarter strength and Product AG. Bioproduct XL at 25% strength increased marketable yield compared with the control while Product AG decreased it.

Significant differences in Shepody total and marketable yields were found with the Bioproduct XL 25% strength and Product AG treatments (Fig. 4). Total yield of plants treated with Bioproduct XL at one-quarter strength produced the highest total yield of 350.4 cwt/acre. Although this was not different from the control, this yield is significantly higher than the total yield from plants treated with Bioproduct XL at half strength, 318.2 cwt/ac. Product AG reduced yield by 98 cwt/acre compared with the control. Marketable yields from Bioproduct treated plants was similar to the control. Marketable yield from Product AG treated seed was only 212.5 cwt/acre, a 29% reduction from the control.

Tubers were graded into <5 cm dia., 5 cm-283 g, >283 g and cull categories. The effect of Bioproduct and Product AG seed treatments on these categories of Russet Burbank tubers is shown in Table 4. Yield of tubers < 5cm in diameter averaged 79.7 cwt/ac and was not affected by the seed treatments used. Product AG reduced the yield of 5 cm-283 g tubers, the Bioproducts did not. Yield of desirable large tubers (>283 g) was highest for Bioproduct XL at one-quarter strength, significantly higher than that from seed treated with half-strength Bioproduct XL. All other treatments were not different from the control. The amount of cull tubers harvested was greatest for the Bioproduct XL 50% strength treatment, yet this only accounted for 7% of the total yield. In general, cullage was small for all treatments.

The yield profile for Shepody is shown in Table 5. Yield of small tubers <5 cm in diameter was significantly lower with Product AG and full strength Bioproduct XL seed treatments when compared with yield from seed treated with one-quarter strength Bioproduct XL. However, these yields are not different that the control. Yield of intermediate sized tubers, 5 cm - 283 g averaged 222.6 cwt/ac for the control and all Bioproduct treatments. Product AG reduced yield of this tuber size category by 46% to 119.2 cwt/ac. Product AG seed treatment however resulted in the highest yield of large tubers >283 g. Yield of large tubers from the full strength Bioproduct XH treatment was only 68% of that from the Product AG treatment. Cull tuber yield was extremely small in this trial (1.2 cwt/ac on average, <1% of total yield) and was not affected by any seed treatment applied.

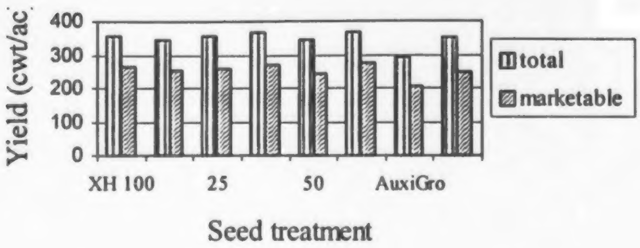


Fig.3. Effect of Bioproducts and Product AG seed treatments on total and marketable yield of Russet Burbank. The * above the bars indicates those treatments which are different from the control at P=0.05.

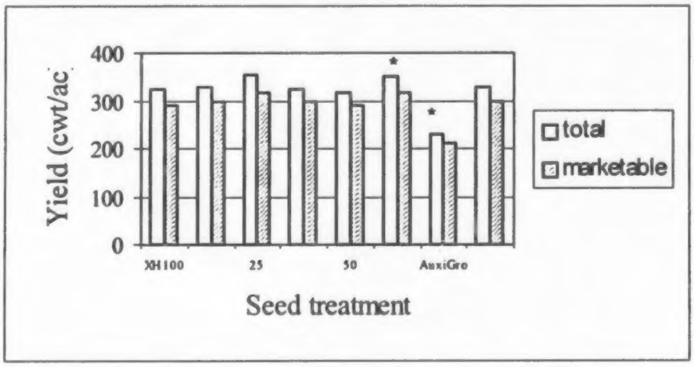


Fig.4. Main effect of Bioproducts and Product AG seed treatment on total and marketable yield of Shepody. The * above the bars indicates those treatments which are different from the control at P=0.05.

Table 4. Main effect of Bioproducts and Product AG seed treatments on Russet Burbank tuber yield

Treatment	<5 cm	5 cm-283 g	> 283 g	Cull
	cwt/ac			
XH 100	81.4a*	200.2a	65.2ab	11.6b
50	76.4a	187.8a	64.3ab	15.4ab
25	80.7a	197.5a	63.8ab	13.3b
XL 100	84.1a	205.7a	63.5ab	15.7ab
50	77.1a	192.5a	51.8b	24.6a
25	80.3a	194.4a	80.9a	12.5b
Product AG	71.6a	150.6b	52.6b	15.9ab
Control	86.0a	185.4a	64.9ab	14.1b

* values within a column followed by the same letter are not significantly differently at P=0.05.

Table 5. Main effect of Bioproducts and Product AG seed treatments on Shepody tuber yield

	<5 cm	5 cm-283 g	> 283 g	Culls
	cwt/ac			
XH 100	30.1ab*	227.4a	63.9b	1.5a
50	26.8ab	215.8a	80.7ab	0.9a
25	29.0ab	233.3a	85.1ab	1.4a
XL 100	24.6b	210.4a	88.4ab	0.7a
50	26.8ab	222.0a	67.5ab	1.9a
25	33.4a	230.7a	85.1ab	1.2a
Product AG	15.8b	119.2b	93.2a	1.6a
Control	28.4ab	219.0a	80.1ab	0.5a

* values within a column followed by the same letter are not significantly differently at P=0.05.

Foliar Applied Product AG. Product AG was applied to the foliage of Russet Burbank and Shepody plants at the tuber hooking stage and again 19 days later. No significant tuber yield effects were found for either Product AG treatment with the cultivars tested (Table 6). Similarly, specific gravity of the Russet Burbank and Shepody tubers was not affected by the foliar treatments.

Although no statistical differences were found with Russet Burbank, the Product AG II treatment, Product AG applied at hooking and 19 days later, tended to increase < 5 cm in diameter, 5 cm to 283 grams, total and marketable tuber yields (Table 6). Average tuber weight in each category was not affected by the Product AG treatments (Table 7).

Tuber yield from Shepody plants sprayed with Product AG at hooking only (Product AG I treatment) tended to have the highest (albeit non-significant) 5 cm-283 gram, total and marketable yields (Table 6). As with Russet Burbank, average tuber weight of Shepody was not affected by the Product AG foliar treatments (Table 7).

Seed Treatment. The potential of three new plant growth regulating compounds to enhance potato plant growth and tuber yields was tested by applying them to Russet Burbank and Shepody tubers before planting. Both whole and cut seed tubers were used to determine if propagule response was concentration dependent.

Seed type (cut or whole) alone influenced emergence and stem numbers of Russet Burbank (Fig.1) and Shepody (Fig.2) but had no effect on plant response to the

Table 6. Tuber yield and specific gravity of Russet Burbank and Shepody plants as affected by foliar applications of Product AG

Treatment	< 5 cm	5 cm-283 g	>283 g	Culls	Total yield	Market. Yield	Specific gravity
R. Burbank*			*Cwt/acre*				
Product AG I	78.5	166.3	32.7	19.1	296.7	199.0	1.0735
Product AG II	88.9	188.8	24.0	16.7	318.5	212.8	1.0743
Control	77.6	175.3	32.3	16.6	301.8	207.6	1.0747
Shepody*			*Cwt/acre*				
Product AG I	30.5	225.6	66.9	0.8	324.0	292.5	1.0779
Product AG II	34.8	204.1	67.7	3.1	309.7	271.7	1.0781
Control	35.2	203.2	77.5	0.8	316.8	280.8	1.0777

* mean separation is not given because no significant differences due to treatment were found.

Table 7. Average tuber weight of Russet Burbank and Shepody tubers after foliar applied Product AG

Treatment	< 5 cm	5 cm-283g	>283g	Culls	Total yield
R. Burbank*		*grams*			
Product AG I	66.3	162.5	352.4	181.3	123.4
Product AG II	72.6	170.9	340.9	193.5	128.6
Control	74.1	171.2	336.8	199.4	134.6
Shepody*			*grams*		
Product AG I	52.2	163.6	348.5	132.4	149.1
Product AG II	46.6	164.8	352.4	163.6	141.3
Control	45.8	161.6	341.2	127.0	141.2

* mean separation is not given because no significant differences due to treatment were found.

Bioproduct treatments. No seed type x treatment interactions were found for any of the parameters measured with any of the treatments. Although it appears that similar Bioproduct concentrations may be used with both cut and whole seed, due to the warm and often dry growing conditions encountered this year, it is difficult to ascertain if seed type is truly not a factor to be considered when applying these products.

Bioproduct XH did not have any significant affect on Russet Burbank or Shepody performance when compared with the control. Continued testing of this product may not be necessary.

Bioproduct XL at the lowest concentration tested (one-quarter strength) showed the most promise at enhancing plant emergence, growth and tuber yield. Even though few significant effects were found, there was a positive trend toward faster emergence and larger plants. Yield increases were statistically significant with this treatment for both Russet Burbank (Fig. 3) and Shepody (Fig. 4). Since stem and tuber numbers were not influenced by the Bioproduct treatment (Table 2), the increase in yield was due to increased tuber size. There were large variations in the number and weight of tubers in the medium and large categories (coefficients of variation ranged from 25%-57%) which could account for the absence of statistical significance between treatments.

Although Russet Burbank and Shepody were not directly compared in this field trial, it is interesting to note that Shepody appeared to be more responsive to the Bioproduct treatments than Russet Burbank. In Fig. 4, there is clearly a trend for increasing total yield with decreasing concentration of both Bioproducts. This trend is not evident with Russet Burbank (Fig.3).

Finally, the 1999 growing season was warmer than normal and soil temperatures at planting were high. Plant emergence was faster than normal, with well over 75% of the plants (treated and untreated) emerged less than 3 weeks after planting. It is possible that the warm temperatures experienced after planting and throughout the growing season masked the full potential benefits of the Bioproducts.

Product AG dusted on the seed of Russet Burbank and Shepody was detrimental to plant development and tuber yields. This was evident by slower emergence (Figs. 1 and 2), smaller plant canopy volume 34-36 days after planting (Table 3) and lower tuber yields (Figs. 3 and 4). With Shepody, stem and tuber numbers per plant were also reduced (Table 2). The higher yield of Shepody tubers >283 g (Table 4) after Product AG treatment is a reflection of Product AG's effect on stem and tuber numbers.

For this study, dry Product AG powder was applied to cut and whole seed at the rate recommended for spraying on the foliage during the growing season. This concentration was clearly toxic to the seed and is not recommended as a dust-type seed treatment. Future research with Product AG to be used as a seed treatment should focus on reducing the amount dusted on seed and applying Product AG in the liquid form to potato seed tubers.

The effectiveness of the Bioproducts to influence plant growth and increase tuber yield can not be conclusively decided from one year's field data. Further studies are warranted. It will be interesting to monitor the influence of the products on plant growth under less than optimal growing conditions.

Foliar Applied Product AG. The application of Product AG to the foliage of Russet Burbank and Shepody plants at the rate and time recommended by the manufacturer had no affect on tuber yield when compared with the control (Table 6). As noted above, the 1999 growing season was hotter than normal. Rainfall at the trial site was also slightly less than normal during the month of August. Temperature and moisture conditions experienced by the plants after treatment may have stressed the plants and influenced product translocation and effectiveness. Additional trials are needed to fully investigate the usefulness of this product to the New Brunswick potato industry.

IMPROVING COLOUR OF POTATO FRENCH FRIES AND CHIPS BY ENZYMATIC MODIFICATION OF REDUCING SUGARS

L' AMÉLIORATION DE LA COULEUR DES FRITES ET DES CROUSTILLES DE POMME DE TERRE PAR UNE MODIFICATION ENZYMATIQUE DES SUCRES RÉDUCTEURS

Amber C. McCulley[1], Patrice Audy[2], George Tai[2], Chantal Matar[3] and/et
Roger L. Bernier[1]

Partners / Partenaires: Agriculture and Agri-Food Canada and Université de Moncton / Ministère de l'Agriculture et de l'Agroalimentaire et Université de Moncton

Abstract: The purpose of this study was to design a cost-effective and recoverable enzymatic process to decrease the amount of reducing sugars in processed potatoes. Phase one of the project involved performing a thorough literature and patent review. In phase two, an experimental model was designed to provide researchers with background knowledge essential to developing efficient and effective methodologies. Model substrates were prepared by freeze-drying different varieties of liquefied potatoes (including Shepody and Russet Burbank). Assays were performed and the amount of reducing sugars was measured before and after enzyme treatments. The results obtained from these models provided a focus for phase three of the project that involved performing frying tests on potato tuber slices subjected to different enzymatic and non-enzymatic treatments. Changes associated with frying, such as colour and flavor, were analyzed.

Résumé: Cette étude avait pour but le développement d'une approche enzymatique peu coûteuse et efficace pouvant abaisser la quantité des sucres réducteurs dans les tubercules de pomme de terre voués à la transformation. La première phase du projet a consisté à faire une revue exhaustive de la litérature et des brevets existants sur le sujet. Dans la seconde phase, un modèle expérimental a été créé pour fournir aux investigateurs des connaissances suffisantes sur le développement de méthologies efficaces et peu coûteuses. Des substrats modèles ont été préparés en lyophilisant des tubercules liquifiés appartenant à différents cultivars (incluant Shepody et Russet Burbank). Pour une unité expérimentale donnée, la quantité de sucre réducteur a été mesurée avant et après chaque traitement enzymatique. Les résultats obtenus avec ces modèles ont conduit aux tests de cuisson des tranches de pomme de terre soumis à différents traitements enzymatiques et non-enzymatiques. Les changements associés avec la cuisson des pommes de terre telles que la couleur et la saveur ont été évalués.

Introduction

High content of reducing sugars is well known to be the limiting factor for the production of fried potatoes with an acceptable light colour. The darkening of potato crisps during processing is the result of a series of reactions collectively known as the Maillard reaction, in which amino groups react with carbonyls supplied by reducing sugars (predominantly glucose and fructose). Major potato varieties, despite their high dry matter content, are considered to be unsuitable for use in the potato industry because of a reducing sugar content up to 0.5%. The rate of browning is accelerated during the frying process as a result of moisture decrease and heat effects.

---

[1] BioAtlantech, P.O. Box 636, Stn A, Fredericton, NB, E3B 5A6 / BioAtlantech , C.P. 636, succ. A, Fredericton, NB E3B 5A6

[2] Agriculture and Agri-Food Canada, Fredericton, NB / Agriculture et Agroalimentaire Canada, Fredericton, NB

[3] Université de Moncton, Moncton, NB, E1A 3E9 / University of Moncton, Moncton, NB, E1A 3E9

Sugar level can be controlled by proper storage of the potatoes prior to processing (Jadhav *et al.*, 1991). Potatoes are stored at low temperature to extend the shelf life of tubers, but storing at 4°C for several weeks increased the activity of starch hydrolyzing enzymes and consequently reducing sugar content (Cottrell *et al.*, 1993). Reconditioning of potatoes by storing them at up to 20°C before they are processed, decreases the amount of reducing sugars but induces sprouting, which then has to be stopped using chemical treatments.

Breeding for improved chip colour and the use of molecular techniques to modify genes thought to be involved in cold temperature stability has also been studied (Coffin *et al.*, 1987; Loiselle *et al.*, 1990). The most common method is leaching sugars by hot water alone or hot water containing an anti-browning agent like Sulfite (Burton, 1989).

Application of enzymes to decrease reducing sugar levels has been studied in the past. Using a glucose oxidase/catalase system, the percentage of glucose was decreased in potato slices leading to a less severe Maillard reaction. (Biekman, 1989 and Jiang *et al.*, 1989). Such an enzymatic process could be performed in the processing/frying plant with the current equipment and within the boundaries of potato factory operation. In addition, partial recovery of enzymes after processing coupled with a higher enzyme/substrate reaction rate could lead to a cost-effective process suitable for chip and french fry production. However, there was great expense associated with such an enzymatic manipulation and the procedure was deemed impractical.

The primary objectives of this project were:

1. To study the effect of different enzyme preparations and non-enzymatic reagents on sugar transformation. Enzymes and reagents screened had a GRAS status (Generally Recognized as Safe), and were commercially available in large quantities. Conditions used throughout the screening process reflected current processing conditions used in potato factories (pH, temperature, salt and water content, etc.)
2. Ideally, to obtain patented technology for a potato processing method that would benefit industry and consumers alike.

Such a treatment would reduce the energy and cost involvement during the reconditioning of potato before processing and avoid chemical treatment to prevent sprouting and/or microbial spoilage. Other advantages to directly processing cold stored potatoes without reconditioning include reducing excessive weight loss due to desiccation and delaying senescent sweetening. Finally, this process could be applied directly to the potato industry without major additional immobilization costs.

Materials and Methods

This project is a cooperative research effort between BioAtlantech and the Université de Moncton with Agriculture and Agri-Food Canada as a contractual technical partner.

The following potato varieties will be used throughout this project: Acadian Russet, Russet Burbank, Shepody, Red Pontiac, Yukon Gold, Atlantic and Raritan

Enzyme Substrate Preparation. Cold-stored potato tubers (4 °C) were used during experimentation. The potatoes were washed, peeled and weighed using a Mettler Toledo PB602 digital scale. The potatoes were then cut into dices approximately 1 cm^3 in volume. These dices were placed into an Osterizer blender and liquefied until a smooth mash was obtained. Periodic breaks in blending allowed the temperature to be monitored and material to be stirred. The pH of the slurry was measured using an Accumet Basic digital pH meter and the weight of the slurry was obtained using the digital scale described earlier. Large weighing dishes were used to hold the potato slurry enabling a greater surface area to be exposed to the freeze-drying process. Potato varieties were not mixed. After blended mixtures were obtained, they were placed in a -80ºC freezer until the freeze-drying process was initiated.

The frozen slurries were placed into a Labconco freeze-dryer and the temperature was set to -56°C. Freeze-drying temperature was gradually increased throughout seven days to promote more rapid water loss. Freeze-dried material was stored in a dessicator with drierite (anhydrous calcium sulfate Stock #23005-W.A. Hammond Drierite Company Ltd.) and protected by aluminum to prevent any undesirable photochemical reactions.

Glucose Standard Preparation. Glucose standard solutions were constructed with the following concentrations of glucose in distilled water (mg/ml): 0.3, 0.5, 0.75. These glucose samples were analyzed following the reducing sugar assay procedure outlined below.

The Reducing Sugar Assay-Phase Two. This assay was created based on the "1,4-β-Xylanase Assay Using Oat Spelts Xylan Substrate and DNSA" standard operating procedure No: SOPO #40-0046 Rev. 6 obtained from Zeneca laboratories. A DNSA (dinitrosalicylic acid) reagent was required for the assay and was prepared by combining 1416 ml of distilled water with 19.8 g NaOH (Fisher BP359-500). After dissolution, 10.6 g of DNSA (Sigma D0550 Lot 66H5023) was added. Once the DNSA mixture was dissolved, 306 g of sodium potassium tartrate (Sigma S2377 Lot 27H0398), 7.6 ml of phenol (Sigma P4557 Lot 48H0590) and 8.3 g of sodium bisulfite (J.T. Baker Lot 511956) were added.

The glucose standard assay was completed in the following manner. Three solutions of glucose (0.3, 0.5, and 0.75m mg/ml) were mixed with 1.0 ml of 1% potato substrate, pre-incubated to 30°C (potato substrate solutions were prepared by adding distilled water to the freeze-dried potato material and mixing). The entire solution was incubated at 30°C for 30 minutes. The DNSA reagent (2 ml) was added and the mixture was placed in a boiling water bath for 15 minutes. The addition of 3.0 ml of distilled water terminated the reaction and the solution was cooled in an ice bath. The solution was vortexed and centrifuged at 3000 rpm for 5 minutes. Centrifugation settled any floating potato substrate material. The top layer of the solution was extracted with a Pasteur pipette and placed in a cuvette. The absorbance was read at 575 nm, zeroing with the blank. The blank was constructed by replacing the original glucose sample with 1.0 ml of distilled water. All trials were completed in triplicate. Absorbance readings throughout the project were obtained using a Beckman DU 530 Life Sciences UV/Vis Spectrophotometer. Based on the absorbance readings obtained from the glucose standards, the concentration of reducing sugars in potatoes could be determined using linear regression and extrapolation.

To perform the assay on the enzyme sample, 1.0 ml of enzyme was used. One ml of 1% potato substrate, pre-incubated to 30°C for 5 minutes, was added. Once again, this yielded a 0.5% potato substrate final concentration and potato solutions were prepared by adding distilled water to the freeze-dried potato material and vortexing. The solution was incubated at 30°C for 30 minutes. The DNSA reagent (2.0 ml) was added and the solution was placed in boiling water bath for 15 minutes. The addition of 3.0 ml of distilled water and cooling in an ice bath terminated the reaction. The solution was vortexed and centrifuged at 3000 rpm for 5 minutes. The absorbance was read at 575 nm, zeroing with enzyme blank. The enzyme blank was prepared by replacing the enzyme with 1.0 ml of distilled water. Enzymes used in this assay are outlined in the Results and Discussion section. Those which yielded a significant decrease or increase in reducing sugar levels were analyzed further in phase three of the project.

Enzymes specific to attacking the amino acid portion of the Maillard reaction were screened in a different manner. Freeze-dried potato substrate was crushed into a powder using a mortar and pestle. Adding the appropriate amount of distilled water created a 2% potato powder solution. The solution was stirred extensively while covered with parafilm. A solution of 2% agar was prepared. Equal amounts of the potato substrate solution was added to the hot agar, mixed well and poured carefully into petri plates. This produced a mixture with a final concentration of 1% agar with 1% potato substrate. Enzymes were spotted on petri plates (5 µl spot volume). The petri plates were incubated at 30°C for 30 minutes. Then, the petri plate surfaces were covered with Coomassie Blue and shaken for 20 minutes. The petri plate surfaces were rinsed with a solution of 45% methanol and 10% Organic Compound "A" solution and the plates were shaken for 30 minutes. A final rinse with 7% Organic Compound "A" solution occurred and the plates shook for 1 hour. Spots were observed where enzymes had an effect on the potato substrate.

Frying Tests-Phase Three. Phase three involved obtaining new cold-stored potato tubers of the same variety. They were washed and cut into approximately 1 mm thick slices. The slices were rinsed individually under cool tap water to remove starch from the surface, inactivate undesirable microorganisms and decrease softening enzyme activity. Three slices of the potato were placed in a beaker containing a certain concentration of the enzyme under study. The final volume of the enzyme solution was 100 ml. The beaker was placed in an incubator at 30°C for 30 minutes and stirred at approximately 95 rpm (revolutions per minute) on an Orbit Shaker. The slices were then removed, rinsed briefly in tap water and deep-fried in heated vegetable oil (Canola Harvest 100% Pure Canola Oil Cholesterol Free) at 350°F. After frying, chip colour and flavor (when safe to taste) were observed.

At certain points throughout the project, to further study what was occurring during the incubation period prior to frying, leached material was often collected in 10 ml aliquots and placed in plastic centrifuge tubes (Corning 430791 15 ml plastic disposable centrifuge tubes). This leached material was sometimes analyzed with protein assays, reducing sugar assays, and nucleic acid assays. The reducing sugar assays were performed as outlined before, however, instead of using the freeze-dried potato matter, a 2 ml volume of the leached material served as the sample. It was not necessary to centrifuge the material after cooling.

The protein assay was performed in the following manner. A protein standard series was created using BSA (bovine serum albumin) solutions at the following concentrations (mg/ml): 0.01, 0.025, 0.05, 0.075, 0.10. Forty µl of BioRad Protein Assay Dye Reagent Concentrate Catalog 500-0006 was mixed with 160 µl of the desired BSA solution. This mixture was vortexed and left to sit 30 minutes at room temperature. A volume of the mixture (100 µl) was withdrawn and placed into a micro cuvette (Beckman Micro Cell 8 mm High 523450. This micro cuvette was place into the spectrophotometer with the aid of a 100 µl Microcell Holder 517613 adapter and the absorbance was read at 600 λ. Distilled water was used in the place of the BSA solution as a blank. All readings were completed in triplicate. When the protein assay was performed on the leached material, the leached fluid was used in place of the BSA solution.

A nucleic acid assay was performed on leached material as well. Leached material (2 ml) was placed into a Precision optical Beckman quartz cuvette and the absorbance was read at 260 and 280 λ. Distilled water was used as a blank. Readings were done with leached material collected at times 0 and 30 minutes after adding the potato slices to the solution.

Results and Discussion

The Literature Search-Phase One. Based on the literature review, the enzymes listed in Table 1 were proposed to manipulate the potatoes.

Table 1. Enzymes

Enzyme	Specific Activity	Units Definition	Preparation Form	Reaction Catalyzed	Reactants	Additional Activities
Pectin lyase Sigma-P3026	2-4 U/mg solid	1 unit causes a ΔA_{235} of 1.0/min at pH 6.0 40°C due to the release of unsaturated products from pectin	Basic enzyme; solution containing 50% glycerol, 50 mM NaOAc buffer, 1 mM PMSF, pH 4.5	Eliminate cleavage of pectin to give oligosaccharides with terminal 4-deoxy-6-methyl-α-D-galact-4-enuronosyl groups	Pectin, 4-deoxy-6-methyl-α-D-galact-4-enuronosyl oligosaccharides, polygalacturonic acid, D-galacturonic acid	No detectable cellulase, hemicellulase, glycosaminidase <20 U/mg protein polygalacturonase
Glucose oxidase Sigma-G9010	Minimum 200 units/mg protein	1 unit oxidizes 1.0µmol β-D-glucose to D-gluconic acid and H_2O_2/min at pH 5.1, 35°C (22.4 µL/min O_2 uptake)	Solution containing 0.1M NaOAc buffer, 0.002% thimerosal as preservative, pH 4	β-D-Glucose + $O_2 \leftrightarrow$ D-Glucono-1,5-lactone + H_2O_2	β-D-Glucose, O_2, D-glucono-1,5-lactone, H_2O_2	0.1 Sigma U/mg protein catalase
Glucose oxidase/catalase Sigma-G7016 Lot 48H3799	100,000-250,000 units per gram solid (without added oxygen)	1 unit oxidizes 1.0µmol β-D-glucose to D-gluconic acid and H_2O_2/min at pH 5.1, 35°C (22.4 µL/min O_2 uptake)	Lyophilized containing 80% protein; balance PO_4 buffer and NaCl	β-D-Glucose + $O_2 \leftrightarrow$ D-Glucono-1,5-lactone + H_2O_2	β-D-Glucose, O_2, D-glucono-1,5-lactone, H_2O_2	10 Sigma U/mg protein catalase. Trace amylase, maltase, glycogenase, invertase, GalO
Glucose 1-Dehydrogenase Sigma-G5909 Lot 28H3788	100-200 units/mg protein (glucose substrate); 50-100 units/mg protein (galactose substrate) at pH 7.0 at 37°C in the presence of $NADP^+$	1 unit oxidizes 1.0µmol β-D-glucose to D-glucono-δ-lactone/min at pH 7.6, 25°C	Chromatographically purified; lyophilized	β-D-Glucose + $NAD(P)^+ \leftrightarrow$ D-Glucose-1,5-lactone + NAD(P)H		
Amine Oxidase Sigma-M4636 Lot 97H7611	40-100 units/g protein	1 unit oxidizes 1.0µmol benzaldehyde/min at pH 7.4, 25°C	Suspension in 2.0M $(NH_4)_2SO_4$, pH 6.0	$RCH_2NH_2 + H_2O + O_2 \leftrightarrow RCHO + NH_3 + H_2O_2$	RCH_2NH_2, H_2O, O_2, RCHO, NH_3, H_2O_2	
L-Amino Acid Oxidase Sigma-A9253 Lot 66H0273	0.3U/mg solid	1 unit oxidatively aminates 1.0µmol L-Phe/min at pH 6.5, 37°C	Crude	An L-amino acid + H_2O + $O_2 \leftrightarrow$ A 2-Oxo acid + NH_3 + H_2O_2	L-Amino acid, H_2O, O_2, 2-oxo acid, NH_3, H_2O_2	

Table 1. (cont.) Enzymes

Enzyme	Specific Activity	Units Definition	Preparation Form	Reaction Catalyzed	Reactants	Additional Activities
α-amylase Sigma-A3176 Lot 38H1141	10-30 U/mg solid	1 unit liberates 1.0 mg maltose from starch/3 min at pH 6.9, 20°C		Endohydrolysis of 1,4-α-D-glucosidic linkages in polysaccharides containing three or more 1,4-α-linked D-glucose units	1,4-α-D-Glucosidic linkages, starch, glycogen, polysaccharides, oligosaccharides, maltose, maltotriose, dextrins	2-10 U/mg solid β-amylase
β-amylase Sigma-A7005 Lot 56H7130	750-1000 U/mg protein	1 unit liberates 1.0 mg maltose from starch/3 min at pH 4.8 20°C	Crystallized suspension in 2.3M $(NH_4)_2SO_4$	Endohydrolysis of 1,4-α-D-glucosidic linkages in polysaccharides to remove successive maltose units from non-reducing ends of the chains	1,4-α-D-Glucosidic linkages, starch, glycogen, polysaccharides, oligosaccharides, β-maltose, 3,5-dinitrosalicylic acid	
Laccase Sigma-L2157	Minimum 50 units/mg solid	1 unit produces a ΔA_{530} of 0.001/min at pH 6.5, 30 °C using syringaldezine as substrate	Crude	4 Benzenediol + $O_2 \leftrightarrow$ 4 Benzosemiquinone + 2 H_2	Benzenediol: oxygen oxidoreductase	
Polygalacturonase Sigma-P3429	300-1500 U/mg protein	1 unit releases 1.0μmol reducing sugar measured as D-glacturonic acid from polygalacturonic acid/min at pH 5.0, 30°C	Purified from pectolyase; suspension in 3.2M $(NH_4)_2SO_4$ and 1mM PMSF, pH 4.5	Random hydrolysis of 1,4-α-D-galacturosiduronic linkages in pectate and other galacturonans	1,4-α-D-Galacturosiduronic linkages, pectin, galacturonans	Pectin lyase. No detectable cellulase, hemicellulase, glycosaminidase
Enzyme	Specific Activity	Units Definition	Preparation Form	Reaction Catalyzed	Reactants	Additional Activities
Papain Sigma-P3375 Lot 18H1485	1.5-3.5 U/mg solid	1 unit hydrolyzes 1.0 μmol BAEE/min at pH 6.2, 25°C	Crude, not stabilized with lactose or other adulterants	Hydrolysis of proteins with a preference for residues bearing a large hydrophobic side chain at the P2 position	Polypeptides benzoyl-L-arginine ethyl ester	
Ascorbate Oxidase Sigma-Lot 48H4057	1000-3000 U/mg	1 unit oxidizes 1.0μmol L-ascorbate to dehydroascorbate/min at pH 5.6, 25°C	Lyophilized containing 10% protein; balance primarily buffers and sucrose as stabilizer.	2 L-Ascorbate + $O_2 \leftrightarrow$ 2 Dehydroascorbate + 2 H_2O	L-Ascorbate, O_2, 2 dehydroascorbate, H_2O	

Table 1. (cont.) Enzymes

Enzyme	Specific Activity	Units Definition	Preparation Form	Reaction Catalyzed	Reactants	Additional Activities
Trypsin Sigma-T7409 Lot 18H7450	1000-2000 BAEE U/mg solid	1 BAEE unit yields ΔA_{253} of 0.001/min at pH 7.6, 25°C with BAEE as substrate; 1 BAEE U:320 ATEE U	Crude	Preferential cleavage: Arg↓, Lys↓	Polypeptides, amides, esters, peptide bonds, p-toluene-sulfonyl-L-arginine methyl ester (TAME)	<IO BTEE U/mg solid chymotrypsin
Lysozyme Sigma-L6876 Lot 111H7010	50,000 U/mg protein	1 unit produces a ΔA_{450} of 0.001/min at pH 6.24, 25°C; suspension of Micrococcus lysodeikticus as substrate in 2.6 ml reaction mixture, 1 cm light path	3x crystallized; diallyzed; lyophilized containing 95% protein; balance primarily NaOAc and NaCl buffer salts	Hydrolysis of 1,4-β-linkages between N-acetylmuramic acid and N-acetyl-D-glucosamine residues in peptidoglycans, and between N-acetyl-D-glucosamine residues in chitodextrins	Peptidoglycan chitodextrins mucopolysaccharides, mucopolypeptides	
Lipase Sigma-L3126 Lot 116H0858	35-70 U/mg protein (triacetin); 110-220 U/mg protein (olive oil)	1 unit hydrolyzes 1.0 µeq fatty acid from triglyceride/hr at pH 7.4, 37°C with triacetin as substrate; 30 min incubation time at pH 7.7 using olive oil as substrate; equivalent to 10µL CO_2/30 min	Crude; containing 25% protein	Triacylglycerol + $H_2O \leftrightarrow$ Diacylglycerol + a carboxylate	Triacylglycerol, H_2O, diacylglycerol, carboxylate; comparative reactivity: triolein (100%), tripalmitin (22%), triaurin (103%), trimyristin (53%), tricuprulin (312%), tricaprin (166%), tripropionin (22%), triacetin (38%)	Amylase and protease
Cellulase Sigma-C0901 Lot 58H3291	5-10 U/mg solid	1 unit liberates 1.0µmol glucose from cellulose/hr at pH 5.0, 37°C (2 hr incubation time)	Powder	Endohydrolysis of 1,4-β-D-glucosidic linkages in cellulose, lichenin and cereal β-D-glucans	1,4-β-D-glucosidic linkages, cellulose, lichenin, β-D-glucan.	
Phenolase Sigma-P4788 Lot 108F9560	300-1000 U/mg protein	1 unit produces a ΔA_{265} of 0.01/min at pH 7.5, 30°C with chlorogenic acid as substrate in 3 ml volume	Lyophilized containing 60% protein; balance KPO_4 buffer salts, DTT, $MgCl_2$, EDTA	2 Catechol + $O_2 \leftrightarrow$ 2 1,2-Benzoquinone + 2 H_2O	Catechol, O_2, 1,2-benzoquinone, H_2O	

The commercial samples of enzymes that are mentioned in Table 2 were tested as well (alone or in conjunction with each other):

Table 2. Commercial samples of enzymes

Fermcolase 1000-Food grade	Genencor	Lot number 301-98331-157	Commercial source of glucose oxidase/catalase
Endo-cellulase-enriched	Pioneer PCI Chemicals, Inc.	A3528	
Exo-cellulase A3760	Pioneer PCI Chemicals, Inc	Lot 853083	
Ecopulp X-200	Pioneer PCI Chemicals. Inc.	Lot 103016233	Microbial hemicellulase enzyme preparation with xylanase activity
Ecopulp TX-200C	Pioneer PCI Chemicals, Inc.	Lot 103107309	Thermostable hemicellulase (xylanase) enzyme preparation
Cellulase ES 9UBO55	Pioneer PCI Chemicals, Inc.		
Cellulase Mixture A233	Pioneer PCI Chemicals, Inc.	Lot 883078	
Ecopulp C-20 Cellulase	Pioneer PCI Chemicals, Inc.		
Ecopulp NC44 Cellulase	Pioneer PCI Chemicals, Inc.		
Ecostone N600	Pioneer PCI Chemicals, Inc.	Lot 102637290	
Ecopulp NC80 Cellulase	Pioneer PCI Chemicals, Inc.		
Ecopulp XM	Alko Ltd.	Lot 4118/562/94	

The Reducing Sugar Assay – Phase Two. Before freeze-drying potato material, data indicated that the temperature of the slurry during blending never raised above room temperature. The data also indicated that the pH of the potatoes was approximately 6. This was in accordance with stated literature values. Freeze-drying produced a fine potato powder when stirred. After freeze-drying, there was an overall decrease in the weight of the potato material which could be explained by the loss of water from the potato.

Absorbance readings obtained from glucose standard solutions closely showed a liner regression between the concentration of sugar and the absorbance. The graphs in Figure 1. depict the results obtained for six potato varieties.

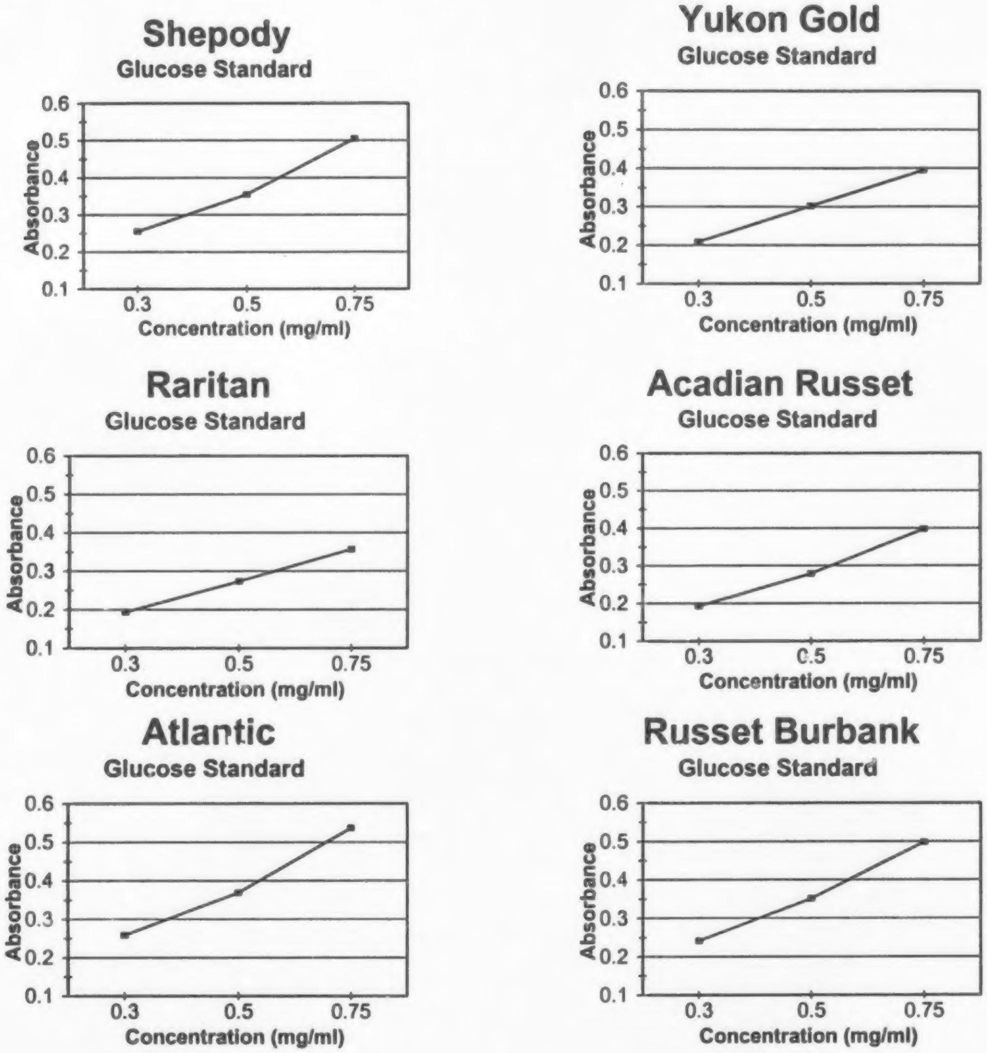


Figure 1. Results obtained for potato varieties

When certain enzymes were applied to the potato substrate, appreciable differences were provided by the reducing sugar assay. A summary of the significant results is shown in Table 3.

Table 3. Summary of reducing sugars assay

Enzyme	Effect
α- amylase	Higher absorbance reading than control
Glucose dehydrogenase	Lower absorbance reading than control
Glucose oxidase/catalase	Lower absorbance reading than control

Other enzymes with potential reducing sugar modifying abilities were tested, however, results were either non-significant or it was non-economical to continue testing with these enzymes. Shepody and Russet Burbank (two major commercial potato varieties) were used as potato substrate for screening procedures. The results are shown in Figure 2. Potatoes of other varieties were conserved as much as possible for more extensive study to follow. Whenever enzyme tests were performed, glucose control solutions were prepared to ensure control graphs were still depicting a straight line prior to reading enzyme results.

Enzymes predicted to modify the amino acid portion of the Maillard reaction were tested with petri plates as described in the Materials and Methods section. L-amino acid oxidase, plasma amine oxidase and trypsin showed a limited cleavage of the substrate on petri plates. It was not economical to continue using L-amino acid oxidase and plasma oxidase beyond this point, however, frying tests with trypsin were performed.

The Frying Tests – Phase Three. Frying tests were performed with the following enzymes because of significant results obtained in phase two of the project: glucose oxidase/catalase, glucose dehydrogenase, α-amylase and trypsin.

The following enzymes underwent frying tests as well because they were relatively unexpensive, readily available or could not be screened in the phase one process: ascorbate oxidase, phenolase, papain, lysozyme, bromelain and lipase.

Concentrations of the enzyme solutions which potato slices were exposed to were varied through the process of trial and error. Glucose oxidase was tested with the following specific activities (U/ml): 0.5, 2.5, 10, 50, 500, 1000, and 2000. Glucose dehydrogenase was more costly, therefore, testing was limited to trials at 88 U/ml and approximately 10 U/ml. α-amylase was tested at 500 U/ml and 2000 U/ml. Trypsin was tested at 250 U/ml in conjunction with 250 U/ml glucose oxidase/catalase. It was also tested at 14200 U/ml and 2000 U/ml. In all cases stated above, no significant difference in potato chip colour could be observed.

Ascorbate oxidase was tested at approximately 25 U/ml. Phenolase was tested at 4.5 U/ml. Papain was tested at 190 U/ml. Lysozyme was tested at (U/ml) 5000,

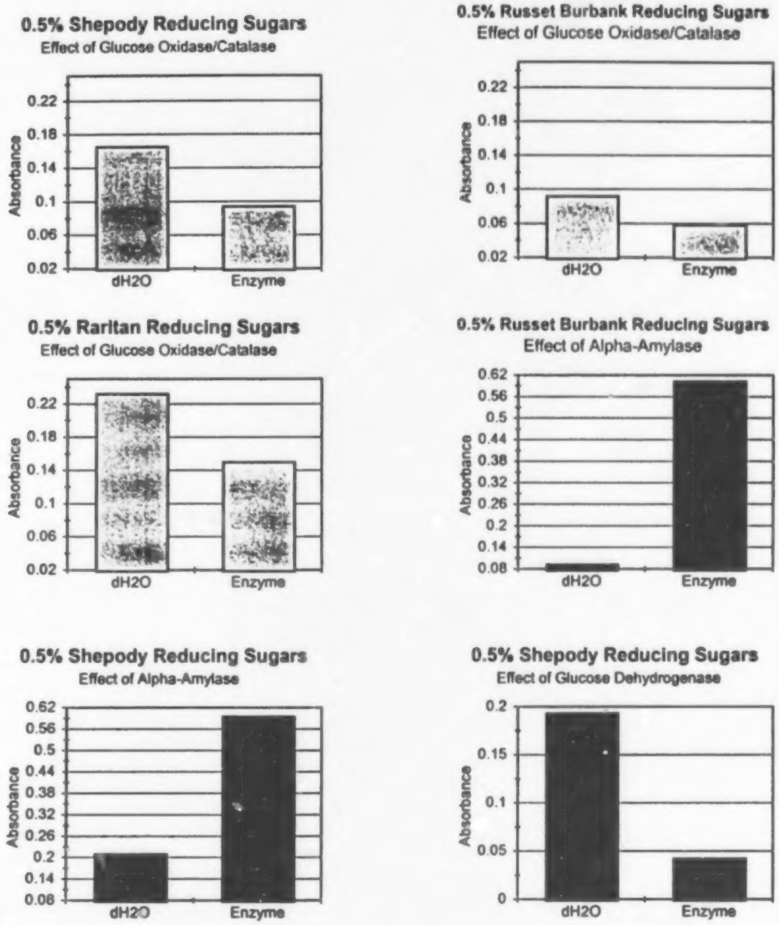


Figure 2. Effects on potato varieties

50,000, 250,000, and 1,000,000. Bromelain was tested at approximately 210 U/ml. No significant differences were observed in chip colour after frying in any of the experiments described above. Once again, frying tests were performed primarily with Russet Burbank and Shepody potato slices.

Because of the non-significant results obtained at this point in phase three of the project, it was necessary to investigate more on the Maillard reaction in potato chips. Potato slices were subjected to differing incubation temperatures (23°C, 30°C, 60°C and 90°C) for 1 hour. Slices exposed to 23°C and 30°C exhibited the same brownish colour after frying. Slices exposed to 60°C produced paler chips and slices exposed to 90°C produced white chips. It should be noted that these latter slices tore easily upon removal from the beaker they were soaking in. This drew attention to the possibility that an inherent cellular structure (ie. cell wall, cell membrane) was being damaged.

Because of the success in obtaining white chips, it was of particular interest to determine if the change in colour was due to the liberation of reducing sugars or amino acids which could no longer take part in the Maillard reaction. A protein assay and a reducing sugar assay were performed on the leached material surrounding the slices exposed to the differing temperatures. Leached material was collected after 10, 15, 30 and 60 minutes. Initially a protein standard series was analyzed using the protein assay to ensure the test was a reliable indicator of protein content.

When the protein levels of the leached material were analyzed, protein levels generally increased in the leached material as time passed. However, considering the dilution factor involved, the assay was not sensitive enough to show significant differences in the amount of protein leached at different temperatures. When the reducing sugar assay was performed, results indicated that reducing sugar levels increased with time only when slices were exposed to temperatures of 60°C and 90°C. As well, overall reducing sugar levels in the leached material were higher at 60°C and 90°C. The graphs in Figure 3 depict these results.

These results indirectly implied that the reducing sugars were being leached from the potato slices at high temperatures likely due to cellular damage. Therefore, enzymes targeted for attacking the cell membrane and cell wall were tested. Potato slices incubated with different forms of lipase underwent frying tests at the following concentrations: 2200 U/ml, 1000 U/ml, 500 U/ml and 6.25 U/ml. No significant differences in chip colour were observed after frying.

It was hypothesized that the enzymes were having difficulty infiltrating into the potato slice where it is necessary to act on reducing sugars or alter the state of the cell wall or membrane. To test this hypothesis, potato slices were washed and placed into a vacuum flask containing Fermcolase (commercial form of glucose oxidase/catalase). The flask was connected to a vacuum for 30 minutes and shaken briefly every 5 minutes. Immediate frying afterwards produced no significant colour differences. It was proposed that infiltration was not effectively occurring with this apparatus. Because experimental apparatus that permitted a more efficient infiltration effect was not economical, this approach was abandoned.

It was necessary to determine whether altering the cell wall and cell membrane integrity was directly related to obtaining pale chips. Therefore, potato slices were placed in a Sonicator (Branson 1510) for differing periods of time (0, 2, 5, 15, 30, 60 minutes). After 30 and 60 minutes, the chips displayed a slight amount of transparency around the edges after frying.

A better way of disrupting the cell integrity needed to be tested, therefore, experiments using high osmolarity were performed. Ammonium sulfate (39g) was added to 100 ml of distilled water and 3 slices of Atlantic potato were left in

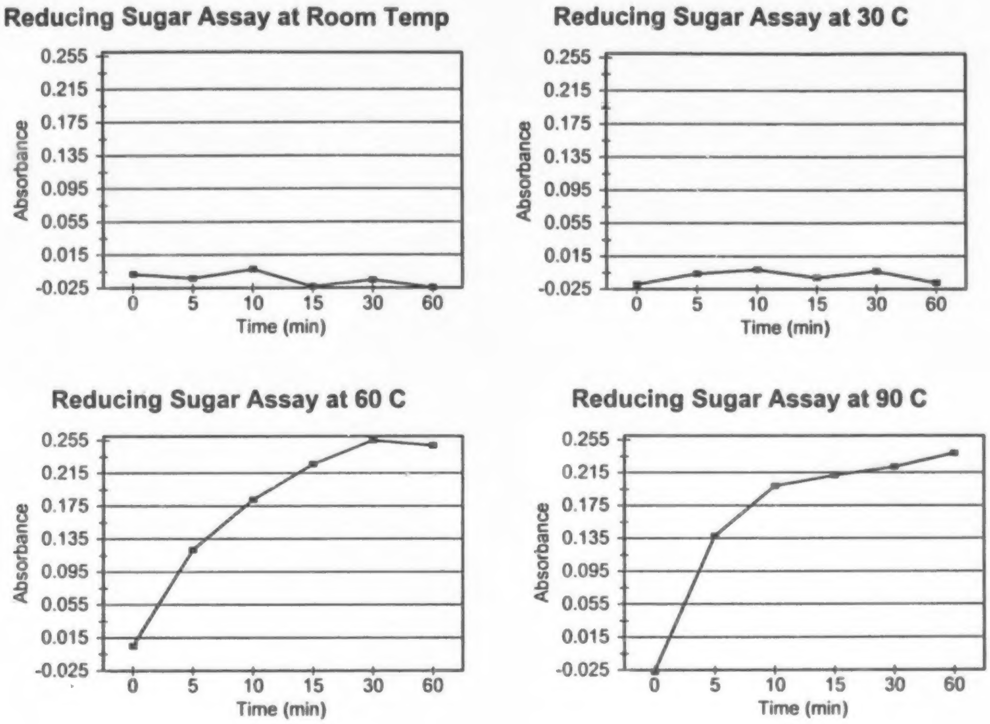


Figure 3. Results of reducing sugar assay

this mixture for 30 minutes at 30°C. A significant colour change was observed after frying as chips obtained were pale. Because ammonium sulfate was not food grade, sodium chloride was tested at the same concentration. Once again, chips produced were pale, however, taste was undesirable due to the excess salt. To assess whether NaCl was producing the same effects observed with high temperatures, a reducing sugar assay was performed on the leached material. The graph shown in Figure 4 depicts the data obtained.

It was discovered that the concentration of NaCl could be lowered to approximately 10% (w/v) and still produce paler chips, however, the taste was very salty. It was predicted that the chloride was the effective factor in the compound, therefore, calcium chloride ($CaCl_2$) was tested. Five grams of calcium chloride in 100 ml of distilled water produced a desirable effect (about half of the amount required with NaCl). Tests were repeated with both of these chloride compounds, however, results were inconsistent throughout potato varieties and sometimes $CaCl_2$ treatment left chips with a slight greenish tint.

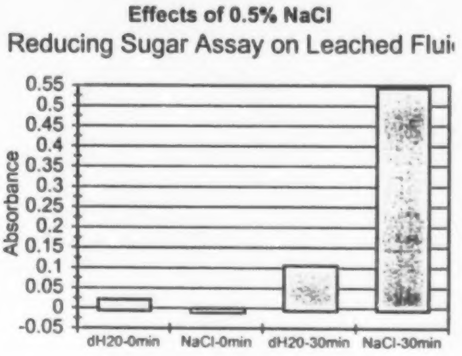


Figure 4. Effects of 0.5% NaCl

To circumvent the negative drawback of using salt, Organic Compound "A" was assessed for its effect on the cell membrane integrity. Much smaller amounts of Organic Compound "A" (0.5 ml in 100ml distilled water) could be used to produce pale chips without any negative effects upon taste. A reducing sugar assay was performed on the leached material to determine if the pale chips were produced as a direct result of leaching of reducing sugars. Results indicated that reducing sugars were being leached from the potato slices at a greater amount when exposed to Organic Compound "A" than when exposed to distilled water. To test the hypothesis that the Organic Compound "A" was damaging the cell membrane and the reducing sugars were being leaching out, a nucleic acid assay was performed to determine if any DNA was present in the surrounding leached materials. Results from the nucleic acid assay are located in Table 4.

These results indicate that the DNA concentration in leached materials is higher (260 nm reading) after the Organic Compound "A" treatment. This implies that cell rupture was occurring.

It was also discovered that addition of minimal amounts of Organic Compound "A" required to lighten the colour of potato chips did not drastically alter the pH of the surrounding immersion solution. This implies that enzymes designed to operate at a specific pH level may be incorporated with the Organic Compound "A" treatment.

It was decided that the Organic Compound "A" treatment along with enzyme exposure might maximize the desirable colour effects and minimize the time required for treatment. Potato slices were exposed to a mixture of 0.5 ml Organic Compound "A" and 0.5 g of Enzyme "B" in 100 ml of distilled water. Slices were sorted according to thickness (1 mm or 2 mm). 1 mm slices were paler than control slices, however, 2 mm slices remained dark. Therefore, it was determined

Table 4. Results from the nucleic acid assay

Contents	Absorbance (260nm)	Absorbance (280nm)
DH_2O-0min	0.127	0.120
DH_2O-60min	0.456	0.409
Organic Compound "A"-0min	0.337	0.386
Organic Compound "A"-60min	0.945	1.021

that chip thickness played a significant role in whether Organic Compound "A" or enzyme or combinations of both would serve as effective treatments for improving chip colour.

Conclusions

It was concluded that potato chip colour could be improved, however, it appears that enzyme treatment is inhibited by diffusion and infiltration problems. It was determined that cell membrane penetration is pertinent to allowing the release of reducing sugars. Once leached, these reducing sugars can no longer take part in the undesired Maillard reaction. Organic Compound "A" serves as a promising approach of creating cellular damage, thus, allowing reducing sugars to be leached. Small amounts of Organic Compound "A" will produce this effect with no negative impact on taste. Because potato chip thickness appears to play a significant role in determining whether the Organic Compound "A" procedure described in this report will be effective, thicker french fries may pose a challenge. The solution may rest in an assay combining Organic Compound "A" and an enzyme (such as a Enzyme "B"). Should this combination serve as a more effective and efficient means of producing pale potato chips and french fries, an enzyme immobilization technique could be developed to minimize the cost.

References

Atlantic Potato Evaluation and Recommending Committee, Potato Variety Registration Trials-Atlantic Region Procedures and Standards. Revised September 1991.

Aukrust, T., Blom, H. ans Slinde, E. 1993. Influence of brine composition on quality of deep-fried fermented carrot chips. A molecular and practical approach to biotechnology of Lactobacilli. By T. Aukrust, *Norwegian Food Research Institute, Norway.*

Biekman, E. 1989. Application of enzymes in processing of potatoes to consumer products. *Voedingsmiddelentechnologie* **22 (20):** 51-53.

Burton, W.G. 1989. The potato. (3rd edn). Longman Singapore Publisher 9PTE) LTD, Singapore, p409.

Brierley, Ewen R., Bonner, Philip L.R., and Cobb, Andrew H. 1996. Factors influencing the free amino acid content of potato (*Solanum tuberosum* L) tubers during prolonged storage. *Journal of the Science of Food and Agriculture* **70:** 515-525.

Carr, Peter, Bowers, Larry 1980. Immobilized enzymes in analytical and clinical chemistry Vol. 56. John Wiley @ Sons, Inc, p185.

Coffin, R., Yada, H., Parkin, K.L. Grodzinski, B., and Stanley, D. 1987. Effect of low storage on sugar concentrations and chip color of certain processing potato cultivars and selections. *Journal of Food Science* **52:** 639-645.

Cottrell, J.E., Duffs, C.M. Paterson, L. Mackay, G.R. and Allison, M.J. 1993. The effect of storage temperature on reducing sugar concentration and the activities of three amolytic enzymes in tubers of the cultivated potato *Solanum tuberosum*. *Potato Research* **36:** 107-117.

Fennema, Owen R. 1985. Food Chemistry. Marcel Dekker, Inc., New York, NY. 434-437 pp.

Jankowski, Kristine M., Parkin, Kirk L., and Von Elbe, Joachim H. 1997. Nonuniform browning or "mottling" in french fry products associated with a heterogeneous distribution of reducing sugars. *Journal of Food Processing and Preservation* **21:** 33-54.

Jadhav, S.J., Mazza, G. and Desai, U.T. 1991. Postharvest and Products, ed. D.K. Salunkhe, S. Kadam, S. and Jadhav, S.J. CRC Press, Inc., Boca raton, FI, USA, p.69.

Jiang, Z., and Ooraikul, B. 1989. Reduction of nonenzymatic browning in potato chips and french fries with glucose oxidase. *Journal of Food Processing and Preservation* **13:** 175-186.

Kaaber, Lene, Sundt, Thea Wenche, and Slinde, Erik. 1995. Production of chips from potato cultivars (*Solanum tuberosum* L.) with high sugar content using lactic acid fermentation. *Potato Research* **38:** 39-45.

Lehninger, Albert L. 1975. Biochemistry Second Edition. Worth Publishers, Inc., New York.

Loiselle, F., Tai, G, C.C. and Christie, B.R. 1990. Genetic components of chip colour evaluated after harvest, cold storage and reconditioning. *American Potato Journal* **67:** 633-646.

Low, N., Jiang, Z., Ooraikul, B., Dokhani, S. and Palcic, M. 1989. Reduction of glucose content in potatoes with glucose oxidase. *Journal of Food Science* **54:** 118-121.

Manan, J.K. *et al.* 1987. Improvement in colour of deep fat fried potato chips from cold stored potatoes by lactic acid fermentation. *Journal of Food Science and Technology* **24:** 139-141.

McMinn, W.A.M., and Magee, T.R.A. 1997. Kinetics of ascorbic acid degradation and non-enzymic browning in potatoes. *Food and Bioproducts Processing* **75:** 223-232.

Ohad, Itzhak *et al.* 1971. Biogenesis and degradation of starch-the fate of the amyloplast membranes during maturation and storage of potato tubers. *Plant Physiology* **47**: 465-477.

Ooraikul, B. and Palcic, M. 1987. Study of glucose oxidase and its use in preventing nonenzymatic browning in potato products. *Farming for the Future*, Alberta Agriculture, Edmonton, Alberta.

Ovsejevi, Karen, Grazú, Valeria, and Batista-Viera, Francisco. 1998. ß-Galactosidase from Kluveromyces lactis immobilized onto thiosulfinate/thiosulfonate supports for lactose hydrolysis in milk and dairy by-products. *Biotechnology Techniques* **12:** 143-148.

Rodriguez-Saona, Luis E., Wrolstad, Ronald E., and Pereira, Cliff. 1997. Modeling the contribution of sugars, ascorbic acid, chlorogenic acid and amino acids to non-enzymatic browning of potato chips. *Journal of Food Science* **62**: 1001-1005.

Slinde, E. *et al.* 1993. Lactic acid fermentation influence on sugar content and colour of deep-fried carrot chips. *Food Research International* **26:** 255-260.

Sowokinos, J.R., Orr, P.H., Knoper, J.A., and Varns, J.L. 1987. Influence of potato storage and handling stress on sugars, chip quality and integrity of the starch (amyloplast) membrane. *American Potato Journal* **64**: 213-226.

Walter, W.M. Jr., Fleming, H.P., and McFeeters, R.F. 1992. Firmness control of sweet potato french fry-type product by tissue acidification. *Journal of Food Science* **57**: 138-142.

White, John Stephen, and White, Dorothy Chong. 1997. Source Book of Enzymes. CRC Press, New York, NY.

EVALUATING POTATO PLANTLET PREPARATION PROCEDURES FOR NUCLEAR SEED PRODUCTION

EVALUATION DE METHODES DE PREPARATION DES PLANTULES DE POMMES DE TERRE DESTINES A LA PRODUCTION DE SEMENCES DE DEPART

Loretta J. Mikitzel[1]

Partner/Partenaire: Mr. Robert Watson, Salmon River Farm

Abstract: This study was initiated to determine if high generation seed potato producers could prepare plantlets for transplanting on their farm and to determine if planting trays (cell packs versus pro-trays) have an effect on plant growth and yield. Russet Burbank and Superior plantlets were transplanted directly from phytotrays into a commercial screenhouse on May 25, 1999 or hardened off in cell packs or pro-trays in a glassed-in porch for three weeks then transplanted on June 15, 1999. Additional plantlets were transplanted directly from phytotrays on June 15, 1999. For Russet Burbank and Superior, plantlets grown in the screenhouse since May 25, 1999 produced the highest yield of tubers and 73% of the tuber yield was accounted for by minitubers weighing more than 40 grams each. For both cultivars, increased yields were due to more tubers being set by the May 25 plants, not an increase in average size of the tubers. Performance of plants hardened off in the cell packs was similar to that of plants hardened off in pro-trays and both produced one-half the yield of the May 25 plants. Hardening off the plants for three weeks lowered minituber yields probably due to recovery time needed for the plants to overcome transplanting shock. Plantlets placed in the screenhouse on June 15 produced the lowest yields and fewest tubers. These plants were growing for only 81 days, compared to 102 days for the other treatments. Planting tray had no effect on plant performance. The length of time potato plantlets grew uninterrupted in the screenhouse had an impact on yield.

Résumé : L'essai avait pour but de déterminer si les producteurs de pommes de terre de semence de génération élevée peuvent préparer les plantules pour le repiquage à la ferme, et de déterminer si les caissettes de semis (alvéolées et pro-trays^{MC}) ont un effet sur la croissance des plants et sur le rendement. Le 25 mai 1999, des plantules de Russet Burbank et de Superior sont passés directement des phytotrays^{MC} à un abri grillagé commercial, et d'autres ont été endurcis dans des caissettes alvéolées ou des pro-trays^{MC} sous abri vitré pendant trois semaines avant le repiquage le 15 juin 1999. Des plantules additionnels ont été repiqués directement à partir des phytotrays^{MC} le 15 juin 1999. Les plantules de Russet Burbank et de Superior cultivés sous abri grillagé depuis le 25 mai 1999 ont donné le meilleur rendement de tubercules, et 73 % du rendement était attribuable aux minitubercules pesant plus de 40 grammes chacun. Pour les deux cultivars, les meilleurs rendements étaient attribuables au plus grand nombre de tubercules produits par les plants semés le 25 mai et à une augmentation du poids moyen des tubercules. La performance des plants endurcis dans les caissettes alvéolées était semblable à celle des plants endurcis dans les pro-trays^{MC}, et les deux techniques ont donné la moitié du rendement des plants semés le 25 mai. Les plants endurcis pendant trois semaines ont donné un moins bon rendement de minitubercules, probablement à cause du temps de récupération nécessaire pour que les plants se remettent du choc du repiquage. Les plantules placés sous abri grillagé le 15 juin ont donné les plus faibles rendements et le moins de tubercules. Ces plants ont poussé pendant 81 jours seulement, comparativement à 102 jours pour les autres traitements. Les caissettes de semis n'ont pas eu d'effet sur la performance des plants. La durée de croissance ininterrompue des plantules sous abri grillagé a eu une incidence sur le rendement.

Introduction

Currently, nuclear seed potato producers have the option of planting microtubers, transplants or plantlets reared in phytotrays. Microtubers are easy to handle but availability may be limited. Phytotray plantlets are economical but require careful handling to avoid damage during planting. Also, intensive management after planting is required to ensure a high survival rate. Transplants are very hardy and establishment success is high because the plants are large with a well-developed root system. However, timing is critical with transplants. If the plants are grown too long in the trays, tubers may set before transplanting and yields may be compromised.

---

[1] Potato and Horticulture Branch, NBDARD, Wicklow, NB E7L 3S4/Direction de la pomme de terre et horticulture, MAARNB, Wicklow, NB E7L 3S4

What is needed is flexibility for the grower to be able to harden off plantlets on-site to produce transplants that are ready at the time and at the growth stage that best suit the grower's production needs. The project proposed here will study a system whereby with minimal capital inputs by the grower, plantlets will be hardened off on the farm. Hardening off plantlets on site eliminates handling and scheduling steps, saving time and money. Conventional hardening off procedures entail transplanting the plantlets from the phytotrays to flats or cell packs, growing them in a greenhouse and shipping the flats to the grower. When the plants are hardened off at the production site, there is no need to maintain a greenhouse or transport the hardened plants in bulky trays. Savings may be realized in cost of plantlets to the grower.

A common transplanting environment is the cell pack. Cell packs are plastic trays divided into compartments of equal length, width and depth. Pro-trays are also divided into compartments; however, the depth of each is three times that of the length or width. Both types of trays are readily available and economical. Pro-trays offer the benefit of a long straight root system at transplanting.

Hardening off the plantlets on the farm gives the grower control over plantlet management and growth environment. The grower is no longer tied to a delivery schedule to plant his crop. The benefits of growing hardened off transplants, ease of transplanting, quicker recovery time after transplanting and improved yields in a shorter period of time are well known.

This study was initiated to compare the performance of plantlets hardened off in cell packs and pro-trays and to determine the suitability of an existing on-farm low-input structure as an environment for preparing plantlets for transplanting.

Materials and Methods

Plantlets of the potato cultivars Superior and Russet Burbank in closed phytotrays were purchased from the Plant Propagation Centre, Fredericton.

On the day of delivery, May 25, 1999, one-third of the plantlets were transplanted directly into the screenhouse, one-third transplanted into cell packs (one plantlet per cell) and one-third transplanted into pro-trays (one plantlet per cell). There were 150 Superior plantlets per treatment and 125 Russet Burbank plantlets per treatment. The plantlets in cell packs and pro-trays were hardened off on-site in an unheated glassed-in porch with supplemental fluorescent lighting under a 15-hour photoperiod. They were planted into sterile peat-based potting medium (ASB Greenworld), watered as needed and fertilized with 20-20-20 weekly.

On June 15, 1999, the cell pack and pro-tray plantlets were transplanted into the screenhouse. An equal number of un-hardened off Russet Burbank and Superior plantlets were transplanted directly from phytotrays into the screenhouse. The project partner managed the plants during the growing season. Plants were top-killed on September 4, 1999 and tubers harvested on October 6, 1999.

All plantlets were planted in the screenhouse on 14-cm centres. The experimental design was a randomized complete block, with four-0.6 m^2 replicates. Plantlet survival rate, total tuber yield, yield profile and tuber number were recorded.

Results

Survival rate of all plantlets and hardened transplants of both cultivars was very good, greater than 90%. The daily minimum relative humidity (Fig. 1) was above 62% from late May to the end of June and this probably contributed to the high survival rate of all plantlets. Also, temperatures during that time were seasonal (Figs. 2 and 3). Daily temperature over the course of the growing season is shown in Fig. 4.

At the time of top-kill, plantlets that were transplanted directly into the screenhouse on May 25 and the plantlets that were hardened off in the cell packs and pro-trays had grown for a total of 102 days. The hardened off plants grew for 21 days in the porch and then 81 days in the screenhouse. The plantlets transplanted into the screenhouse on June 15 experienced an 81-day growing season.

The differences in growing season length (time plantlets were grown outside the phytotrays) are reflected in the minituber yields (Table 1).
For both cultivars tested, Russet Burbank and Superior:

- plantlets planted directly in the screenhouse on May 25 had the highest yield
- cell pack and pro-tray transplants produced similar yields, approximately half of that from the May 25 transplants
- plantlets planted on June 15 produced the lowest yield, only one-sixth of that of the plantlets transplanted on May 25
- plantlets planted on June 15 produced significantly fewer tubers per plant and per square meter than all other treatments
- plantlets transplanted on May 25 produced the largest minitubers, on average 35.6 g/tuber for Russet Burbank and 35.2 g/tuber for Superior.

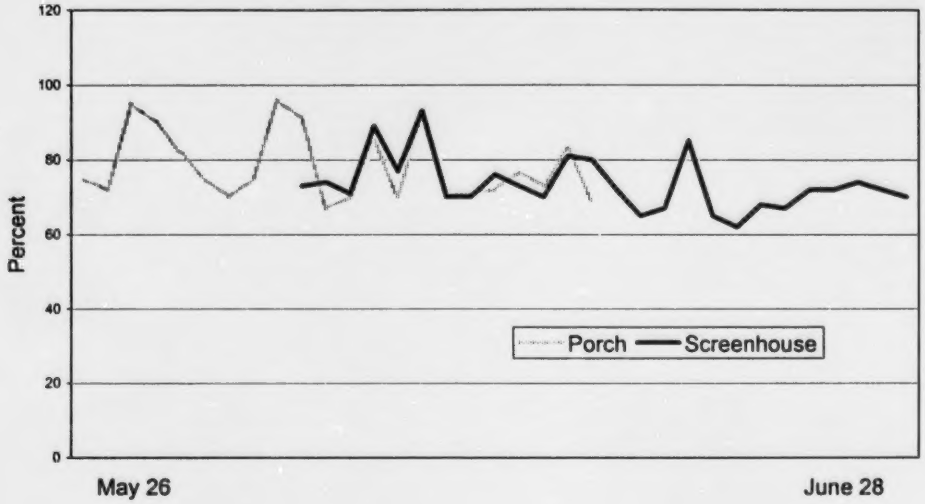


Fig. 1. Minimum relative humidity recorded at plant level during plantlet establishment in the screenhouse and hardening off in the glassed-in porch from May 26, 1999 to June 28, 1999 at Salmon River Farm.

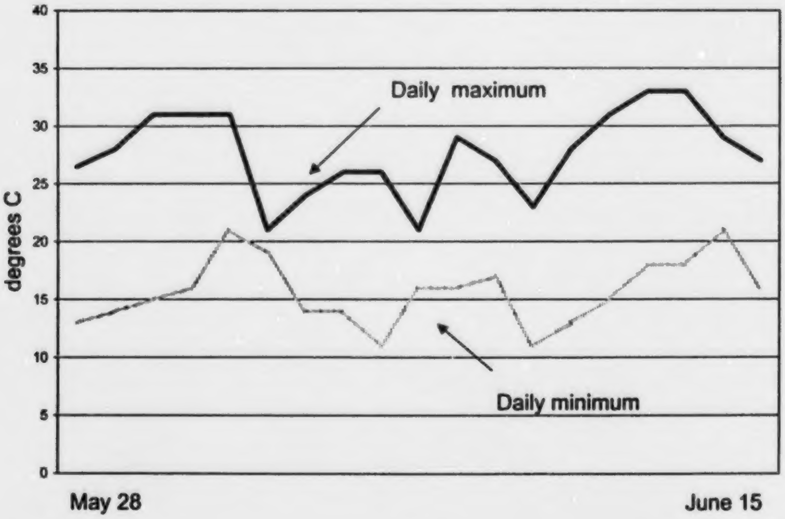


Fig. 2. Daily maximum and minimum air temperature at plant level in the screenhouse from May 28,1999 to June 15, 1999 during the establishment of plantlets transplanted on May 25, 1999 at Salmon River Farm.

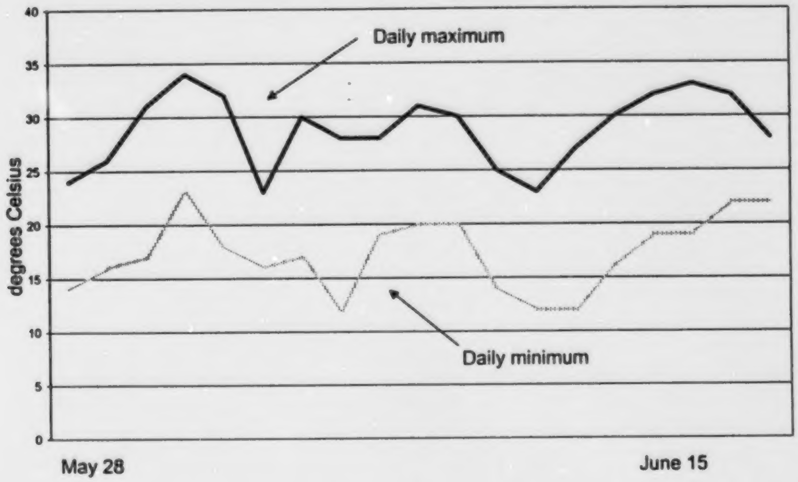


Fig.3. Daily maximum and minimum air temperature at plant level in the glassed-in porch at Salmon River Farm during plantlet hardening off from May 28, 1999 to June 15, 1999.

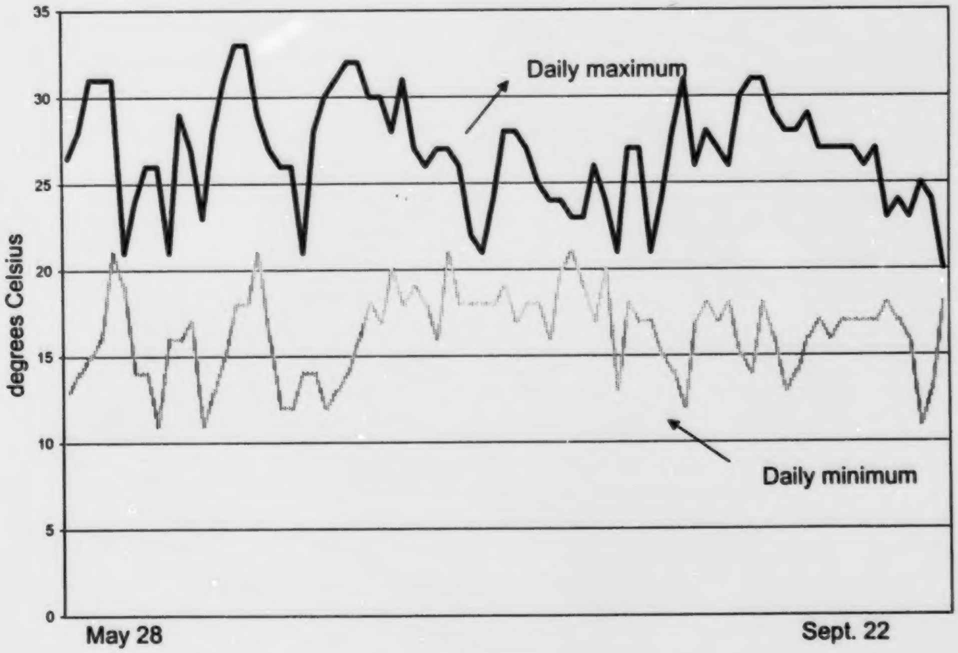


Fig. 4. Daily maximum and minimum air temperature at plant level in the screenhouse at Salmon River Farm from May 28, 1999 to September 22, 1999.

Table 1. Total minituber yield and number, and average minituber tuber weight and number of Russet Burbank and Superior potatoes grown in a screenhouse

Cultivar	Planting	Total /m^2		Average	Tuber #
	Treatment	Yield (g)	Tuber #	tuber wt	per plant
Russet Burbank	May 25/99	4,062.2	113.3	35.6	2.8
	Cell Packs	2,128.2	100.4	20.6	2.2
	Pro-tray	2,339.0	117.9	19.6	2.6
	June 15/99	677.7	41.7	15.0	0.9
	Lsd$_{0.05}$*	1,3131.2	28.3	6.9	0.6
Superior	May 25/99	6,218.7	176.7	35.2	3.7
	Cell Pack	3,114.0	192.1	16.5	3.8
	Pro-tray	2,945.3	174.2	17.1	3.5
	June 15/99	1,022.9	88.8	11.6	1.9
	Lsd$_{0.05}$	1,768.0	31.5	10.5	0.6

* Lsd$_{0.05}$ = least significant difference at P=0.05%.

Table 2 shows minituber yield divided into <5 g, 5-20 g, 20-40 g and >40 g size categories. Of particular interest are the smallest and largest size categories. The smallest tubers are undesirable because they are too small for direct planting in the field. Minitubers that are >40 g are desirable for seed because they produce the most vigorous plants and if large enough, they may be cut to give several seedpieces. Yield of Russet Burbank tubers weighing <5 g was small for all treatments and plants transplanted on June 15 produced the least, 25.8 g/m^2. Superior cell pack transplants produced a higher yield of <5 g minitubers than plantlets transplanted directly into the screenhouse on May 25 or June 15.

The yield of >40 g minitubers from Russet Burbank plantlets transplanted on May 25 was significantly higher than the other three treatments (Table 2). Russet Burbank plantlets transplanted on May 25 produced 2,982.3 g/m^2 of minitubers >40 g, which accounted for 73% of the total yield. In comparison, yield of >40 g minitubers from cell pack and pro-tray transplants, while similar, accounted for only 59% and 54% of total yield, respectively. Less than 50% of the total yield was comprised of >40 g minitubers for the Russet Burbank June 15 transplants.

The trend in yield of >40 g minitubers from Superior plants was similar to that of Russet Burbank (Table 2). Yield of >40 g minitubers (4,547.0 g/m^2) from plantlets transplanted on May 25 was significantly higher than the other three treatments and accounted for 73% of the total yield. Yield of >40 g minitubers from cell pack and pro-tray transplants accounted for only 33% and 32% of total yield, respectively. Less than 45% of the total yield was comprised of >40 g minitubers for the June 15 Superior transplants.

Table 2. Minituber yield profile of Russet Burbank and Superior potato plants grown in a screenhouse

Cultivar	Planting Treatment	Tuber yield (g/m^2) < 5 g	5-20 g	20-40 g	> 40 g
Russet Burbank	May 25/99	39.5	296.7	743.5	2982.3
	Cell Packs	45.5	315.0	518.3	1249.2
	Pro-tray	51.8	304.3	709.3	1273.5
	June 15/99	25.8	127.9	195.7	328.2
	Lsd$_{0.05}$*	17.7	155.8	--	749.5
Superior	May 25/99	70.7	584.7	1,016.5	4,547.0
	Cell Pack	108.7	862.0	1,111.7	1,031.7
	Pro-tray	92.8	835.8	1,077.8	938.9
	June 15/99	68.8	235.7	269.8	448.5
	Lsd$_{0.05}$	27.8	251.0	316.2	1,935.5

* Lsd$_{0.05}$ = least significant difference at P=0.05%.

The number of minitubers produced in each size category (Table 3) mirrors the trends in minituber yields. For both cultivars tested, plantlets transplanted on May 25 produced significantly more >40 g tubers than the other treatments and plantlets transplanted on June 15 yielded the fewest minitubers in almost all size categories. Russet Burbank cell pack and pro-tray transplants produced similar numbers of tubers in all size categories except <5 g and the number of tubers in the size categories 5-20 g and 20-40 g were no different than that from the plantlets transplanted on May 25. The number of minitubers Superior plantlets hardened off in cell packs or pro-trays produced were similar for all minituber size categories (Table 3). Cell pack and pro-tray Superior plantlets produced more <5 g and 5-20 g tubers than did plantlets transplanted on May 25.

For both cultivars, planting treatment had a significant effect on average minituber weight in the smaller tuber size categories (Table 4), and no effect on the weight of 20-40 g or >40 g tubers or 5-20 g Russet Burbank tubers. In Russet Burbank, pro-tray plantlets produced the smallest <5 g tubers. Even though this reduction in weight was statistically significant, the practical impact is negligible. Compared with the other Superior treatments, plantlets transplanted on June 15 produced significantly smaller <5 g tubers and tubers 5-20 g. Weight of pro-tray and cell pack tubers in those size categories were similar.

Table 3. Number of Russet Burbank and Superior minitubers produced per square meter in a screenhouse

Cultivar	Planting Treatment	Tuber number/m^2			
		< 5 g	5-20 g	20-40 g	> 40 g
Russet Burbank	May 25/99	24.2	25.0	23.8	40.3
	Cell Packs	30.8	33.3	16.7	19.6
	Pro-tray	43.3	28.3	25.0	21.2
	June 15/99	16.2	12.9	7.1	5.4
	$Lsd_{0.05}$*	11.3	12.8	--	9.8
Superior	May 25/99	32.0	50.0	33.8	60.8
	Cell Pack	59.2	74.6	40.0	18.3
	Pro-tray	49.7	70.0	38.8	15.8
	June 15/99	48.7	22.9	10.4	6.7
	$Lsd_{0.05}$	16.2	18.7	9.8	19.2

* $Lsd_{0.05}$ = least significant difference at P=0.05%.

Table 4. Average weight of minitubers in each size category

Cultivar	Planting Treatment	Average tuber weight (g)			
		< 5 g	5-20 g	20-40 g	> 40 g
Russet Burbank	May 25/99	1.6	12.0	32.4	73.3
	Cell Packs	1.5	9.0	31.3	61.7
	Pro-tray	1.2	10.8	28.0	56.8
	June 15/99	1.6	10.2	27.1	44.7
	$Lsd_{0.05}$*	0.3	--	--	--
Superior	May 25/99	2.2	11.4	29.8	71.9
	Cell Packs	1.8	11.3	27.5	55.1
	Pro-tray	1.9	11.8	27.6	59.4
	June 15/99	1.4	5.8	25.5	60.4
	$Lsd_{0.05}$	0.4	2.1	--	--

* $Lsd_{0.05}$ = least significant difference at P=0.05%.

Discussion

Results of this trial suggest that, regardless of cultivar, plantlets hardened off in cell packs and plantlets hardened off in pro-trays perform the same after being transplanted into a screenhouse. By comparing cell pack and pro-tray plantlets within a cultivar, they have similar minituber yield, yield profile, minituber number and average minituber weight (Tables 1-4). It appears that neither planting tray is superior to the other: potato plantlets can be hardened off in cell packs or pro-trays with similar plant performance.

Minituber yields from hardened off plantlets were significantly lower than that of plantlets grown in the screenhouse from May 25, 1999 (Table 1) even though hardened plantlets and plantlets set in the screenhouse on May 25, 1999 experienced the same length of time growing outside the phytotray, 102 days. Temperatures in the screenhouse and porch were comparable until June 15, 1999 (compare Fig. 2 and 3) and the plantlets in the porch did not appear to be stressed. The extra handling the plantlets received when transplanted twice (once into growing trays and once into the screenhouse) probably shocked the plantlets, slowing growth and reducing minituber yield.

Also, after three weeks in the glassed-in porch, no plantlets had a root system that was developed enough to form a 'plug' or hold together when the plantlet was removed from its growing tray. Damage to the small root system during transplanting would set the plants back and may also have contributed to reduced minituber yields. To overcome this problem and potentially improve minituber yields, the plants could be hardened off longer, say 4-5 weeks instead of three.

By comparing performance of plantlets transplanted to the screenhouse in May to that of the June 15 transplants (Table 1-4), this trial clearly shows the impact of growing season length on minituber yield. The longer plantlets are grown in the screenhouse, the higher the tuber yield. It also appears that plantlet growth should be uninterrupted for maximum yield. Hardened plantlets and May 25 transplants both grew for 102 days yet yield from the hardened transplants was reduced. To compensate for transplanting shock and the extra handling, it may be necessary to begin hardening off the plantlets before the normal planting date. This would extend the growing season and allow for a maximum number of days of uninterupted growth in the screenhouse.

ACCELERATED RELEASE FRENCH FRY CLONE EVALUATION, WOODSTOCK, NB, 1998 -1999

ÉVALUATION DE CLONES DE POMMES DE TERRE APTES À LA PRODUCTION DE FRITES EN VUE D'UNE MISE EN CIRCULATION ACCÉLÉRÉE, WOODSTOCK (N.-B.) 1998-1999

Peter K. Scott[1] and/et Janet McLaughlin[1]

Partner / Partenaire: New Brunswick Potato Agency (SPUDTECH) / Agence de la Pomme de Terre du Nouveau Brunswick (SPUDTECH)

Abstract: A trial to assess the performance of potential french fry clones developed at the Potato Research Centre of Agriculture & Agri-Food Canada, Fredericton was conducted during 1998 and 1999. A total of nine clones from the 1998 (AR 98) Accelerated Release Program were evaluated during 1998-1999 and an additional five clones from the 1999 (AR 99) Release were tested in 1999 only. Only two AR 98 clones (AR98-28, AR98-46) produced lower total yields than the controls Shepody and Russet Burbank and only AR 98-28 had a lower marketable yield. AR 99-24 produced a higher total yield than the controls and all AR 99 clones were equal for marketable yield. All AR 98 clones produced equal specific gravities and all AR 99 clones produced higher specific gravities than the controls. Four AR 98 clones had a length-to-width ratio lower than Shepody and only AR 99-42 was slightly better than Shepody. In general, most clones produced good french fry color from storage but AR 98-28 and AR 98-73 did produce lower french fry scores late in the 1998-1999 storage season.

Résumé: Un essai réalisé en 1998 et 1999 a permis d'évaluer la performance de clones potentiellement aptes à la production de frites, qui ont été mis au point au Centre de recherches sur la pomme de terre d'Agriculture et Agroalimentaire Canada à Fredericton. On a évalué en 1998-1999 un total de neuf clones faisant partie du programme de mise en circulation accélérée de 1998, et cinq autres clones du programme de mise en circulation accélérée de 1999 ont été évalués en 1999 seulement. Seuls deux clones de 1998 (AR98-28 et AR98-46) ont donné des rendements totaux inférieurs à ceux des variétés témoins Shepody et Russet Burbank, et seul le AR98-28 a donné un moins bon rendement commercialisable. AR99-24 a donné un rendement total plus élevé que les variétés témoins, et tous les clones du programme de mise en circulation accélérée de 1999 ont donné un rendement commercialisable semblable. Tous les clones du programme de mise en circulation accélérée de 1998 avaient une densité semblable, et tous les clones du programme de 1999 avaient une plus grande densité que les variétés témoins. Quatre clones testés en 1998 avaient un ratio longueur-largeur inférieur à celui de Shepody, et seul le ratio du AR99-42 était un peu meilleur que celui de Shepody. En général, la plupart des clones ont donné une belle couleur de frites après l'entreposage, mais les clones AR98-28 et AR98-73 ont obtenu une moins bonne cote pour la couleur des frites à la fin de la période d'entreposage de 1998-1999.

Introduction

Starting in 1998, the Potato Research Centre of Agriculture and Agri-Food Canada introduced the *Accelerated Release Program*, a mechanism to fast track the release of promising potato clones to the frozen french fry industry. This program offers to the industry a number of potential french fry clones for a two year period of non-exclusive field testing. This non-exclusive phase is the first of two steps leading to exclusive commercialization of the new frozen french fry clones.

---

[1] Potato and Agricultural Resource Centre, NBDARD, 39 Barker Lane, Wicklow, NB E7L 3S4 / Centre des ressources de la pomme de terre, MAARNB, 39, allée Barker, Wicklow, NB E7L 3S4

The Research Centre of Agriculture and Agri-Food Canada (AAFC) in Fredericton is known for its active role in the development of improved potato cultivars. The Fredericton breeding program has traditionally been involved in all phases of the process from cross design to cultivar release (12- to 15-year cycle). With the increasingly active participation of the private sector in the development of improved cultivars, this is an attempt to seek an alternative and more timely transfer of improved material to the industry.

In 1998, it was decided to investigate the potential of these new french fry clones on behalf of the New Brunswick Potato Industry. This was made possible through support and funding of the NB Potato Agency and the SPUDTECH research subcommittee. A total of nine potential clones were obtained from Agriculture and Agri-Food Canada at a cost of $100 per clone in 1998 for evaluation and an additional five clones were obtained in 1999. The seed provided by Agriculture and Agri-Food Canada is a 'breeder's class' of seed which is not permitted to be planted on a farm presently producing seed potatoes.

This report covers both the 1998 and 1999 growing seasons. The 1998 Accelerated Release French Fry clones were evaluated for two seasons and includes data collected from the 1998-1999 storage season for fry color and sugar accumulation. Only 1999 field data is presented for the AR 99 clones.

Materials and Methods

This trial consisted of 25 ft-long single row plots in a randomized complete block design with four replications. An additional amount of material was also produced and put into storage at the Potato Storage Management Centre for future storage evaluations and testing. Planting was conducted by hand into rows opened by the cooperating grower using a commercial 4-row planter. In 1998, a 14-14-17 fertilizer and in 1999 a 15-15-15 analysis fertilizer was each banded at row opening at a rate of 1100 lbs/acre. An in-row spacing of 14 inches (35 cm) was used for each clone and Russet Burbank while Shepody was at 12 inches (30 cm). All plots were planted with precut suberized seed at a 2 ounce (58 g) average weight and treated with a fungicide dust.

All plots were dug with a single row plot harvester, placed into mesh bags, and then transported to the Potato Storage Management Centre for future grading. Each sample was hand graded into 6 size categories (1 = <2"; 2 = 2"– 2 1/4"; 3 = 2 ¼" - 2 ¾"; 4 = 2 ¾ - 3"; 5 = 3"- 3 7/8", 6 = > 3 7/8") and then sorted for internal and external defects. Marketable yields are reported as total yield less external defects and <2" size. Stem counts were made soon after full emergence. Hollow heart and brown center determination was conducted on the two largest size categories from each sample and specific gravity was determined using the weight-in-air/weight-in-water method again using the largest size categories.

Storage samples consisting of 20 large tubers of each clone were selected from the multiplication material, stored at 10° C and tested for french fry color and tuber sugar content on a monthly basis from October 1998 to May 1999. Ten tubers were used for french fry color determination from which a single 50 mm x 15 mm disc was sliced from the centre of each tuber. These ten discs were fryed at 190°C for 2 minutes 30 seconds and color was measured using a Model 35D Agtron. Sucrose and glucose determinations were made using a Model 2700 Select YSI analyzer.

Results and Discussion

The 1999 trial was planted on May 31st and the 1998 trial was planted on June 8th, after the cooperating grower had finished his commercial planting. This reliance on a cooperating grower to utilize his equipment for row-opening can cause delays in planting thus reducing the crop season. 1998 had a top kill date of September 17th for a 101 day season and 1999 had a top kill date of September 15th for a 107 day season.

Both the 1998 and 1999 growing seasons were relatively dry with 1999 having an extended dry period from planting through July. Total rainfall for May through July averaged only 85% of normal followed by 120% of normal for August, however this was received in only two rainfall events which did not provide for soil uptake and resulted in losses due to run-off. With the relatively dry conditions late blight was not a problem either year and insect and weed problems were easily controlled.

Over the two seasons only two of the AR 98 series produced lower total yields than the Shepody and Russet Burbank controls; these were AR 98-28 with 219.7 cwt/ac and AR 98-46 with 289.5 cwt/ac (Table 1). AR 98-28, AR 98-46 and AR 98-64 produced marketable yields significantly lower than the controls. Most AR 98 clones produced acceptable tuber length and were equal or superior to Shepody with the exception of AR 98-37 and AR 98-46 which produced relatively round tubers that would not be suitable for french fry processing. The specific gravity of all clones was equal to or better than the controls.

Table 2 presents the size distribution of tubers for each of the clones with only AR 98-28 producing a lower percentage of tubers greater than 2 inches than Russet Burbank. The extremely dry conditions in 1999 provided for a reduction in tuber sizing as can be seen with the Russet Burbank control that produced 57.2 cwt/ac less than 2 inches.

Table 1. Total and Marketable Yields including length x width ratios and specific gravity for AR 98 Series Accelerated Release French Fry Clone Evaluation – 1998-1999

	Total	Marketable	L x W	Specific Gravity
	Cwt/acre			
AR 98-19	380.7 a	330.4 a	1.39	1.0777 b
AR 98-28	219.7 e	174.2 e	1.56	1.0858 ab
AR 98-37	340.3 abc	280.4 abc	1.21	1.0803 b
AR 98-46	289.5 d	211.6 de	1.27	1.0895 a
AR 98-55	328.4 cd	265.5 bcd	1.42	1.0827 ab
AR 98-64	366.8 abc	219.1 cde	1.85	1.0779 b
AR 98-73	329.7 bcd	238.9 bcd	1.91	1.0894 a
AR 98-82	359.8 abc	285.6 ab	1.62	1.0848 ab
AR 98-91	338.7 abc	255.4 bcd	1.65	1.0857 ab
SHEPODY	362.3 abc	258.1 bcd	1.52	1.0779 b
R BURBANK	376.9 ab	287.7 ab	2.47	1.0813 ab
LSD 0.05	41.5	56.5		0.0076
CV	12.36			

*Numbers followed by different letters within each column are significantly different at the 5% level by Duncan's multiple comparison test.

Table 2. Tuber size distribution including total as a percent over 2 inches for AR 98 Series Accelerated Release French Fry Clone Evaluation – 1998-1999

	Size Distribution[1]						
	1	2	3	4	5	6	7
	Cwt/acre						%
AR 98-19	27.2	43.2	158.7	71.3	80.2	0.0	92.8
AR 98-28	34.5	54.3	94.9	23.7	12.2	0.0	84.3
AR 98-37	22.2	30.3	106.3	59.3	115.9	6.4	93.5
AR 98-46	15.4	21.5	67.4	56.8	122.9	5.6	94.7
AR 98-55	44.4	39.5	148.8	53.6	42.1	0.0	86.5
AR 98-64	27.1	45.9	154.3	73.6	65.9	0.0	93.7
AR 98-73	28.3	35.7	107.0	62.5	91.8	4.4	91.4
AR 98-82	24.9	41.2	127.2	72.6	89.2	4.7	93.1
AR 98-91	27.7	31.2	119.9	71.7	87.5	0.7	91.8
SHEPODY	19.7	31.5	122.2	74.9	113.0	0.9	94.6
R BURBANK	57.2	98.6	162.1	39.0	20.0	0.0	84.8

[1] 1 = <2"; 2 = 2" – 2 ¼"; 3 = 2 ¼" - 2 ¾"; 4 = 2 ¾ - 3"; 5 = 3" – 3 7/8", 6 = > 3 7/8" and 7 = >2".

The greatest differences in the clones can be seen with internal and external defects (Table 3). Rough tubers were observed both years with AR 98-64 and AR 98-73 producing more than Russet Burbank but all clones produced less than the Shepody control. Russet Burbank produced the highest amount of tubers with knobs and growth cracks over all the clones. Sunburn was a serious problem both years with only AR 98-55 having less than Russet Burbank and several clones with more than Shepody. Scab was also very evident in these clones with AR 98-64 and AR 98-46 having a greater incidence than Shepody. The total amount of defects was the greatest as a percentage of total yield for both AR 98-64 at 33.7% and AR 98-46 with 27.2% over the control Shepody with 24.5 %. Tubers with hollow heart and brown centre was extremely high with AR 98-46 producing an equivalent of 21.8 cwt/ac.

All clones ranged between 3.3 and 5.3 stems per plant compared to the controls with 3.7 and 3.8. Tubers per plant were all lower than Russet Burbank and only AR 98-46 produced lower tuber numbers than Shepody (Table 4).

The data presented here is for the first year of a two-year nonexclusive investigation into the AR 99 series of the Accelerated French Fry Release program. Table 5 presents the total and marketable yield of these clones with a single year length x width measurement and specific gravity. AR 99-24 produced the greatest total yield at 418 cwt/ac of all the clones including the control varieties Shepody and Russet Burbank. Only AR 99-51 produced a lower yield than either of the controls at only 293.6 cwt/ac. AR 99-24 produced the highest marketable yield at 319.4 cwt/ac followed by AR 99-33 at 270.1 cwt/ac. Only AR 99-42 had a comparable tuber length to Shepody with many clones having only an oblong tuber type with length x width ratios between 1.25 and 1.47. The highest gravities were obtained by AR 99-15 at 1.0852 and AR 99-33 at 1.0861, both greater than the controls. Very low gravities were experienced in 1999 with AR 99-24 and Russet Burbank at 1.0754 and 1.0751, respectively.

Tuber size distribution for the AR 99 series exhibits the effect of the dry growing conditions where no tubers greater than 3 7/8" were produced in 1999 (Table 6). This is also evident with Russet Burbank producing 75.2 cwt/ac of tubers less than 2" in diameter. The AR 99 clones produced a marketable tuber size percentage of between 87.7 and 94.9 % compared to Shepody at 93.3 and Russet Burbank at 78.8%.

Table 7 presents the internal and external defects for the AR 99 series. Shepody produced the highest amount of rough tubers at 19.5 cwt/ac followed closely by AR 99-24 at 15.1 cwt/ac and AR 99-42 with 13.4 cwt/ac. Again Russet Burbank produced the highest amount of tubers with knobs at 22.5 cwt/ac and AR 99-24 followed with 14.2 cwt/ac. Only a small amount of tubers with growth cracks were observed in 1999 and the only AR 99 clone having any was that of AR 99-

Table 3. Internal and external defects expressed as yield and total defects as percent of total yield for AR 98 Series Accelerated Release French Fry Clone Evaluation – 1998-1999

	Internal & External Defects						Total
	Rough	Knob	GC	SB	Scab	HH/ BC	
	Cwt/acre						%
AR 98-19	3.4	0.0	0.0	17.8	1.9	6.1	7.7
AR 98-28	0.0	0.7	0.4	7.7	2.2	0.4	5.2
AR 98-37	4.2	2.1	0.7	22.1	2.2	0.0	9.2
AR 98-46	4.7	1.3	0.0	17.2	33.7	21.8	27.2
AR 98-55	1.3	0.0	1.4	1.7	14.1	0.0	5.6
AR 98-64	11.2	2.1	0.8	42.1	64.5	3.0	33.7
AR 98-73	10.3	0.3	0.0	42.4	5.1	3.7	18.7
AR 98-82	4.2	2.7	0.8	29.6	7.3	0.0	12.4
AR 98-91	2.7	0.0	1.0	45.8	5.3	0.7	16.4
SHEPODY	14.7	2.5	2.2	38.4	25.7	5.4	24.5
R BURBANK	9.0	12.4	4.0	6.6	0.0	0.8	8.7

*Total defects determined as percent of total yield.

GC=growth cracks; SB=sunburn;HH/BC=hollow heart/brown centre

Table 4. Stems per plant and tubers per plant for AR 98 Series Accelerated Release French Fry Clone Evaluation – 1998 – 1999

	Stems per plant	Tubers per plant
AR 98-19	4.9	9.5
AR 98-28	3.7	6.7
AR 98-37	5.1	7.7
AR 98-46	4.1	5.9
AR 98-55	3.3	9.4
AR 98-64	4.1	8.1
AR 98-73	3.8	7.0
AR 98-82	3.7	8.3
AR 98-91	5.3	7.3
SHEPODY	3.7	6.1
R BURBANK	3.8	9.6

Table 5. Total and marketable yields including length x width ratios and specific gravity for AR 99 Series Accelerated Release French Fry Clone Evaluation – 1999

	Total	Marketable	L x W	Specific Gravity
	Cwt/acre			
AR 99-15	356.8 b	263.3 ab	1.47	1.0852 ab
AR 99-24	418.9 a	319.4 a	1.31	1.0754 d
AR 99-33	312.1 bc	270.1 ab	1.25	1.0861 a
AR 99-42	314.5 bc	233.5 b	1.57	1.0813 bc
AR 99-51	293.6 c	188.5 b	1.25	1.0807 bc
SHEPODY	356.6 b	245.5 ab	1.52	1.0803 c
R BURBANK	353.8 b	236.3 b	2.47	1.0751 d
LSD 0.05	49.92	72.95		0.0044
CV	9.77			

*Numbers followed by different letters within each column are significantly different at the 5% level by Duncan's multiple comparison test.

Table 6. Tuber size distribution including total as a percent over 2 inches for AR 99 Series Accelerated Release French Fry Clone Evaluation –1999

	Size Distribution[1]						
	1	2	3	4	5	6	7
	Cwt/acre						%
AR 99-15	43.9	62.9	164.3	51.7	33.9	0.0	87.7
AR 99-24	21.2	28.8	123.7	121.9	123.4	0.0	94.9
AR 99-33	22.1	30.9	130.3	79.3	49.4	0.0	92.9
AR 99-42	35.9	63.7	147.9	42.5	24.4	0.0	88.6
AR 99-51	21.0	30.3	137.1	61.6	44.5	0.0	92.9
SHEPODY	22.0	30.1	140.2	73.5	90.8	0.0	93.8
R BURBANK	75.2	111.1	125.6	24.8	17.2	0.0	78.8

[1] **1 = <2"; 2 = 2" – 2 ¼"; 3 = 2 ¼" - 2 ¾"; 4 = 2 ¾ - 3"; 5 = 3" – 3 7/8", 6 = > 3 7/8" and 7 = >2".**

Table 7. Internal and external defects expressed as yield and total defects as percent of total yield for AR 99 Series Accelerated Release French Fry Clone Evaluation – 1999

	Internal & External Defects						Total*
	Rough	Knob	GC	SB	Scab	HH/ BC	
	Cwt/acre						%
AR 99-15	4.3	0.0	0.0	20.9	24.2	0.0	15.1
AR 99-24	15.1	14.2	3.2	41.1	4.7	0.0	18.7
AR 99-33	0.0	0.0	0.0	7.4	12.5	0.0	6.4
AR 99-42	13.4	2.2	0.0	29.5	0.0	0.0	14.3
AR 99-51	3.4	0.0	0.0	4.9	75.3	0.0	28.5
SHEPODY	19.5	2.4	3.9	29.1	34.1	1.6	25.4
R BURBANK	6.9	22.5	2.6	10.4	0.0	0.0	12.0

*Total defects determined as percent of total yield.
GC=growth cracks; SB=sunburn;HH/BC=hollow heart/brown centre

24. Scab again in 1999 was a problem with Shepody producing 34.1 cwt/ac and providing the greatest amount of grade out in this trial. The only clone with more scab than Shepody was AR 99-51 at 75.3 cwt/ac but also included AR 99-15 at 24.2 cwt/ac, AR 99-33 at 12.5 cwt/ac and AR 99-24 with only 4.7 cwt/ac. Shepody was the only one to produce tubers with hollow heart and only at 1.6 cwt/ac. The lowest amount of total defects was observed with AR 99-33 at only 6.4% followed by control Russet Burbank at 12% of total yield.

AR 99-42 and AR 99-15 produced higher stems per plant than Russet Burbank with 4.4 and 4.9 stems compared to Russet Burbank with 3.8 (Table 8). AR 99-15 produced a very high number of tubers per plant at 11.4 even higher than Russet Burbank at 9.3 tubers per plant.

This report covers the storage data collected during the 1998-1999 storage season from the AR 98 series only. In general, all AR 98 clones produced acceptable french fry color from storage compared to the control varieties Shepody and Russet Burbank. Table 9 presents the four week french fry color results as USDA fry color scale and Table 10 presents this data as Agtron units. Each test is based upon the average of the 10 disc sample. The higher the agtron unit the lighter the fry color and the lower the USDA reading the lighter is the fry color. Although, most clones produced comparable or better fry color from storage than the Shepody and Russet Brubank controls; AR 98-28 and AR 98-73 did not produce superior color late in the storage season in 1999.

Table 8. Stems per plant and tubers per plant for AR 99 Series Accelerated Release French Fry Clone Evaluation – 1999

	Stems per plant	Tubers per plant
AR 99-15	4.4	11.4
AR 99-24	3.9	7.8
AR 99-33	3.4	8.6
AR 99-42	4.9	8.8
AR 99-51	2.9	8.3
SHEPODY	3.1	6.2
R BURBANK	3.8	9.3

Table 9. Accelerated Release French Fry Color[1] Results – Florenceville, New Brunswick (1998 – 1999)

	Oct. 15/98	Nov. 10/98	Dec. 07/98	Jan. 05/99	Feb. 01/99	Mar. 01/99	Mar. 29/99	Apr. 26/99	May 05/99
AR 98-19	1.2	1.3	1.3	1.1	1.1	1.4	1.6	1.2	1.1
AR 98-28	2.4	1.9	2.1	1.3	2.0	3.2	2.7	2.7	2.3
AR 98-37	1.0	1.0	1.3	1.0	1.0	1.1	1.0	1.3	1.2
AR 98-46	1.3	1.1	1.4	1.0	1.4	1.4	1.1	1.0	1.0
AR 98-55	1.1	1.7	1.6	1.4	1.5	1.2	1.1	1.8	1.2
AR 98-64	1.2	1.8	1.1	1.1	1.3	1.1	1.1	1.2	1.2
AR 98-73	1.8	1.3	1.7	1.8	2.0	2.9	2.8	2.3	2.4
AR 98-82	1.3	1.0	1.1	1.2	1.4	1.6	1.5	1.2	1.3
AR 98-91	1.0	1.1	1.0	1.0	1.0	1.1	1.2	1.1	1.1
SHEPODY	1.7	2.1	1.5	1.9	2.7	2.0	1.9	2.3	1.7
R BURBANK	1.3	1.7	1.8	2.0	2.0	2.2	2.2	1.9	1.6

---

[1] USDA Color Rating Average

Table 10. Accelerated Release French Fry Color[1] Results – Florenceville, New Brunswick (1998 – 1999)

	Oct. 15/98	Nov. 10/98	Dec. 07/98	Jan. 05/99	Feb. 01/99	Mar. 01/99	Mar. 29/99	Apr. 26/99	May 25/99
AR 98-19	93.8	91.5	92.1	98.3	96.3	89.0	87.8	94.9	95.3
AR 98-28	74.4	82.4	76.5	90.3	79.9	58.9	63.6	66.9	74.1
AR 98-37	98.6	99.5	94.1	99.6	98.4	96.0	98.5	93.4	94.6
AR 98-46	91.3	98.6	90.8	100.0	89.1	84.9	97.9	98.3	99.0
AR 98-55	93.2	87.4	85.1	88.4	87.7	94.4	93.5	82.6	91.1
AR 98-64	93.6	83.4	95.1	95.2	94.5	93.5	97.6	95.8	91.1
AR 98-73	82.4	91.6	83.6	81.9	78.5	61.0	66.9	76.4	72.6
AR 98-82	91.4	95.9	98.4	94.2	92.9	87.3	85.9	93.3	93.1
AR 98-91	98.0	98.4	100.0	99.9	97.8	96.0	94.6	96.8	97.8
SHEPODY	85.3	77.1	85.9	82.0	69.5	77.5	82.3	74.2	85.3
R BURBANK	93.5	84.0	79.1	78.6	76.7	75.8	74.9	81.1	84.3

[1] Agtron Color Rating Average

Conclusion

The data in this report covers two years of field evaluation and one storage season for the 1998 Accelerated Release french fry clone material from Agriculture and Agri-Food Canada, Potato Research Centre, Fredericton. Also, included is the first year field data for the 1999 Release french fry clones.

After two years of non-exclusive evaluation of nine potential french fry clones (Accelerated Release), none could be clearly identified as exhibiting superior performance over all aspects that were conducted as part of this project. Under the field production and management practices provided during 1998-1999, most clones produced tuber lengths that were less than that of the controls and would produce only acceptable french fry lengths as required to supply New Brunswick's processing industry.

New potato varieties suitable for processing are needed by New Brunswick potato growers and the New Brunswick Potato Agency (SPUDTECH) should continue evaluating newly released potato clones from all potato breeding programs including the Potato Research Centre, Agriculture and Agri-Food's Fredericton program.

Acknowledgements

The authors wish to thank Ralph Culberson & Sons for their excellent management of this trial and SPUDTECH and the Strategic Partnership Development Fund for their funding. Appreciation is also extended to summer assistance provided by Philip Davis.

EVALUATING SEEDPIECE TREATMENT EFFECTS ON PLANT STAND

EVALUATION DES EFFETS DE TRAITEMENTS DES SEMENCES SUR LE PEUPLEMENT

Loretta J. Mikitzel[1] and/et Peter K. Scott[1]

Partner / Partenaire: New Brunswick Potato Agency / Agence de la pomme de terre du Nouveau-Brunswick

Abstract: In 1999 at Hartland, NB, a trial was conducted to evaluate the effectiveness of the various seed treatments available to potato growers in controlling seed piece decay. Potato (*Solanum tuberosum* 'Shepody') seedpieces were dusted with thiophanate methyl (Easeout), mancozeb (Tuberseal, Clean Crop and Dithane), lime, metiram (Polyram 16), fludioxinil (Maxim), or mancozeb + thiophanate methyl (50/50 and 75/25 Tuberseal/Easeout) the day before planting. Control seed pieces were not dusted. At planting, soil temperature was high, plants emerged rapidly, and few seed pieces decayed. In general, very few differences were observed between the various seedpiece treatments used. Initially, seed treated with Maxim emerged slower ($P<0.05$) and seed treated with the Tuberseal + Easeout mixtures emerged faster ($P<0.05$) than the control. These differences disappeared by 21 days after planting. There were no statistical differences in stems per plant, tubers per plant or total yield between seed treatments tested and the control. Total yield ranged from 315 cwt/acre (Maxim) to 352 cwt/acre (75% Tuberseal/ 25%Easeout mixture). For all treatments, marketable yields accounted for 92% of total yield. Because temperature and soil conditions early in the 1999 season were conducive to rapid plant growth and uniform emergence, few advantages to seed treatment were found.

Résumé : Un essai réalisé à Hartland (N.-B.) en 1999 a permis d'évaluer l'efficacité de divers traitements des semences que les producteurs de pommes de terre peuvent utiliser pour éliminer la pourriture des plantons. Les traitements ont consisté à saupoudrer les plantons (*Solanum tuberosum* 'Shepody') avec du thiophanate-méthyl (Easeout), du mancozèbe (Tuberseal, Clean Crop et Dithane), de la chaux, du métirame (Polyram 16), du fludioxinil (Maxim), ou du mancozèbe + thiophanate-méthyl (Tuberseal/Easeout 50/50 et 75/25) le jour précédant la plantation. Un lot de plantons n'a pas été traité. Comme la température du sol était élevée lors de la plantation, les plants ont levé rapidement et peu de plantons ont pourri. En général, on a observé très peu d'écarts entre les divers traitements utilisés. Comparativement à la parcelle témoin, la levée des semences traitées au Maxim a été plus lente ($P<0,05$), et la levée des semences traitées avec des mélanges de Tuberseal + Easeout a été plus rapide ($P<0,05$). Ces écarts avaient disparu 21 jours après la plantation. Aucune différence statistique n'a été observée dans le nombre de tiges par plant, le nombre de tubercules par plant ou le rendement total entre les semences traitées et celles non traitées. Les rendements variaient de 315 quintaux l'acre (Maxim) à 352 quintaux l'acre (mélange de Tuberseal et de Easeout 75/25). Les tubercules commercialisables comptaient pour 92 % du rendement total avec tous les traitements. Comme la température et l'état du sol au début de la saison de 1999 ont favorisé la croissance rapide des plants et une levée uniforme, nous n'avons pas trouvé beaucoup d'avantages à traiter les semences.

Introduction

During the 1998 growing season, several potato fields in the Potato Belt of New Brunswick suffered from erratic emergence and uneven plant stand due to seed piece decay.

---

[1] Potato and Horticulture Branch, NBDARD, Wicklow, NB/ Direction de la pomme de terre et horticulture, MAARNB, Wicklow, NB

The dry rot fungus *Fusarium* is primarily responsible for seed piece decay. It may be held in check by planting well-suberized seed pieces, whole intact seed tubers or seed pieces treated with a protective fungicide. In 1999, we conducted this trial to compare the effectiveness of the various seed treatments available to New Brunswick potato growers in controlling seed piece decay.

The use of lime as a seed treatment is common in New Brunswick. It effectively dries the cut surface of the seed piece and prevents seed from sticking together so it flows evenly through the planter. However, lime does not possess any fungicidal properties and does not affect the growth of the *Fusarium* organism. Lime was included in this trial to compare its performance to the chemical seed treatments.

Materials and Methods

E3 Shepody seed tubers were cut into 71-gram seed pieces and dusted with the seed piece treatments listed in Table 1 at the recommended label rate the day before planting.

Control seed pieces received no seed treatment. Additional untreated control seedpieces were pre-cut and suberized for 7 days.

Seed pieces were planted at the farm of Mr. Robert Seeley, Hartland, NB on May 18, 1999 in a randomized complete block design with four replicates. Plots were 7.6 meters long with seedpieces spaced 30 cm apart in the row. The plots received 1,204 kg/ha 15.7-18.3-18.3 fertilizer (plus Zn and B) and were maintained by the grower co-operator. Rate of emergence and stem number per plant were recorded. Plants were top-killed 120 days after planting and harvested two weeks later.

Total yield of harvested tubers was determined and the tubers were graded into the following categories: culls, < 5 cm diameter, 5 cm diameter - 283 grams and > 283 grams. Marketable yield was calculated by subtracting the weight of cull and < 5 cm diameter tubers from the total yield.

All date were subjected to ANOVA and means were separated by the Duncan's multiple range test at P=0.05%.

Results and Discussion

In general, there were very few differences observed between the various seedpiece treatments used. Emergence of seed treated with any of the commercially available seed treatments (Fig. 1) was not different than that of the untreated control. By 23 days after planting, emergence was almost complete.

Table 1. Trade name and active ingredient of seed piece treatments applied to freshly cut Shepody seed tubers the day before planting

Seed treatment	Seed treatment
Easeout - thiophanate methyl	Maxim - fludioxinil (a phenylpyrrole)
Tuberseal - mancozeb + Douglas Fir bark	Dithane - mancozeb
Lime - Calcium carbonate	50 % Tuberseal + 50% Easeout
Clean Crop - mancozeb	75 % Tuberseal + 25% Easeout
Polyram 16 - metiram	

Initially, seed treated with Maxim emerged slower ($P<0.05$) and seed treated with the Tuberseal + Easeout mixtures emerged faster ($P<0.05$) than the control (Fig 2). These differences were very short-lived and by 21 days after planting no more differences were found. Plant stand was 97% or more for all plots within one month of planting. Virtually none of the seed pieces decayed and plant growth and yield results may represent what can be expected in the absence of seed piece decay pressure.

Table 2 shows stem and tuber number per plant as well as total and marketable tuber yields. There were no statistical differences in stems per plant (average 2.9), tubers per plant (average 5.8), total yield (average 333.3 cwt/acre) or marketable yield (which accounted for 92% of total yield for each treatment) between any seed piece treatment tested and the control. Average tuber weight and specific gravity were not affected by any seed treatment and averaged 6.3 ounces and 1.081, respectively.

Although total yield was not significantly affected by seed treatment, the range in total yield between treatments was 37 cwt/acre: 315 cwt/acre for Maxim-treated seed to 352 cwt/acre for the 75% Tuberseal/ 25% Easeout mixture-treated seed.

Yield profile was not affected by seed piece treatment (Fig.3). There was no statistical difference between treatments in any size category of tubers produced.

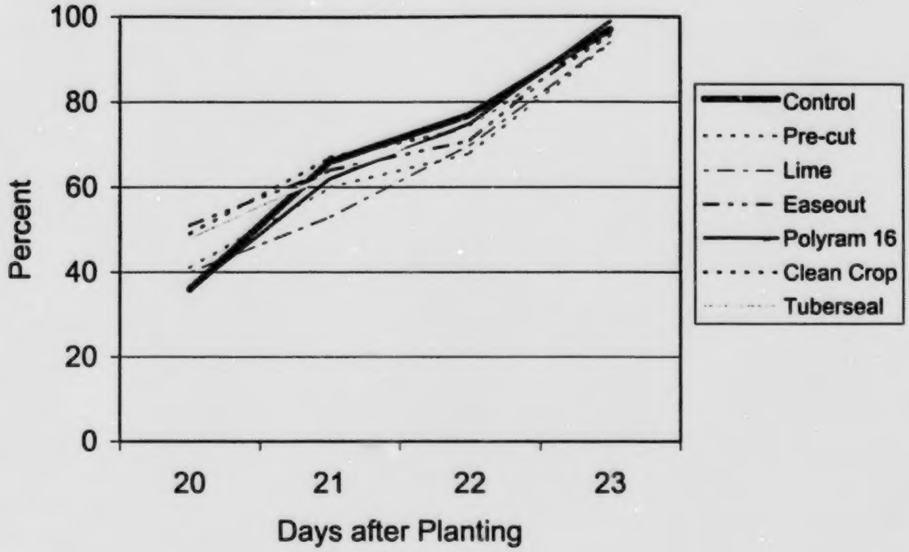


Fig. 1. Emergence of Shepody plants from seed pieces treated with commercially available potato seed piece treatments.

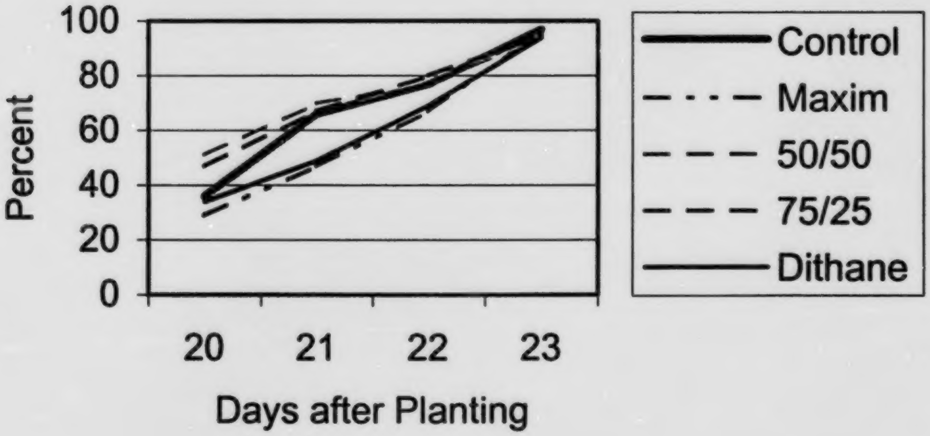


Fig 2. Emergence of Shepody plants from seed pieces treated with potato seed piece treatments not yet registered in Canada. The 50/50 and 75/50 treatments are 50% Tuberseal + 50% Easeout and 75% Tuberseal + 25% Easeout, respectively.

Table 2. Stem and tuber numbers, and tuber yield of Shepody after receiving various seed treatment.

Treatment	Stem # /plant	Tuber# /plant	Total yield (cwt/acre)	Market yield (cwt/acre)
Control	2.6	6.1	347.1	320.4
Pre-cut	3.0	6.1	325.6	296.2
Lime	2.7	5.6	334.8	309.4
Easeout	2.7	5.4	320.9	297.9
Polyram 16	3.1	5.8	329.3	302.8
Clean crop	3.0	5.7	342.0	317.1
Tuberseal	3.0	5.8	324.7	299.9
Maxim	2.8	5.5	315.3	291.2
50/50	3.0	5.8	336.9	312.4
75/25	3.0	6.4	352.6	324.5
Dithane	2.8	5.6	322.5	295.7
Source of variation				
Treatment	ns*	ns	ns	ns

* ns= not significant at P=0.05%.

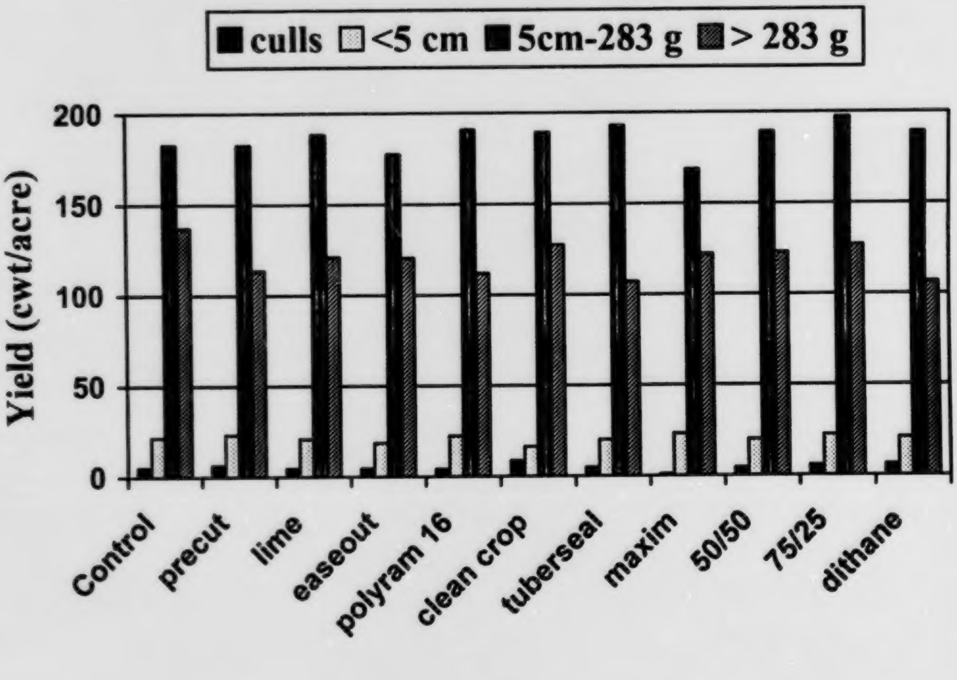


Fig. 3. Shepody tuber yield profile as influenced by seed piece treatment. No statistical difference was found in the yield of any tuber size category and the control due to seed treatment.

Conclusion

Because temperature and soil conditions early in the 1999 season were conducive to rapid plant growth and uniform emergence, few advantages to seed treatment were found.

The results reported here are from the trial conducted over a single field season. This trial will be repeated during the 2000 growing season, and will be expanded to include 4 additional seed piece treatments. Observations will be made and recorded regarding rhizoctonia, scab and silver scurf development after seed piece treatment.

OPTIMIZING THE ECONOMICAL RETURN OF POTATOES THROUGH GREENSPROUTING AND SPACING

OPTIMISATION DE LA RENTABILITÉ DES POMMES DE TERRE GRÂCE À LA PRÉGERMINATION ET À L'ESPACEMENT

Lynn Moore[1]

Partner / Partenaire: New Brunswick Seed Potato Growers' Association / Association des Producteurs de Pommes de Terre de Semence du N.-B.

Abstract: In 1997, seed of four potato varieties was greensprouted and planted in replicated 25 foot single row plots at three spacings : 7", 9" and 11". Emergence was measured 18, 24 and 31 days after planting (DAP), and stem counts were taken 43 DAP. The varieties Penta, Russet Norkotah and Shepody were topkilled 70 and 85 DAP and the levels of the common potato viruses PVY° and PLRV were determined using the ELISA sprout test on harvested tubers. The variety Atlantic was harvested at 74, 80 and 86 DAP and Agtron values were measured for chip colour. All potatoes were counted and weighed into numerous size categories depending on end use, including total and marketable. A delay in planting and the development of white sprouts on the control seed pieces resulted in little effect by greensprouting on emergence, stem counts or yields. Virus levels were higher for Penta and Russet Norkotah at the later topkill date. Under these conditions with the variety Atlantic, greensprouting only advanced emergence by a few days and did not affect stem count, specific gravity or yields. It only positively affected chip colour mid August at the closest spacing. There was a yield benefit for all four varieties in the reduction of in-row spacing from 11" to 7".

Résumé : En 1997, des semences prégermées de quatre variétés de pommes de terre ont été plantées en rangs simples de 25 pieds, et les plantons ont été espacés de 7 pouces, 9 pouces et 11 pouces. La levée a été mesurée 18, 24 et 31 jours après la plantation (JAP), et le dénombrement des tiges a eu lieu 43 JAP. Un défanant a été utilisé sur les variétés Penta, Russet Norkotah et Shepody 70 jours et 85 JAP. Le dépistage du virus Y et du virus de l'enroulement de la pomme de terre a été fait au moyen de la technique ELISA sur des germes de tubercules récoltés. La variété Atlantic a été récoltée 74, 80 et 86 JAP, et les valeurs Agtron ont été mesurées pour la couleur des croustilles. Toutes les pommes de terre ont été comptées, pesées et classées dans de nombreuses catégories de grosseur, selon l'utilisation finale. Les rendements total et commercialisable ont été établis. Comme la plantation a été retardée et que des germes blancs étaient apparus sur les semences témoins, la prégermination a eu peu d'effet sur la levée, le nombre de tiges et les rendements. Les concentrations de virus étaient plus élevées dans les Penta et les Russet Norkotah à la date du dernier défanage. Dans ces conditions, la prégermination d'Atlantic n'a avancé la levée que de quelques jours, et elle n'a pas eu d'effet sur le nombre de tiges, la densité et le rendement. Elle n'a eu d'effet positif sur la couleur des croustilles qu'à la première récolte et à l'espacement le plus étroit (7 pouces). Toutes les variétés ont bénéficié, quand au rendement, d'une réduction de l'espacement de 11 pouces à 7 pouces entre les semences.

Introduction

New Brunswick has traditionally been an important seed potato area, producing the second largest acreage of seed potatoes in Canada. Since the early 1990's, NB has been Canada's largest seed potato exporting province. Increased acreage grown for the processing industry over the years has made it difficult, however, for seed growers to maintain the quality of their seed crops. As a result, a number of seed growers have abandoned the cultivation of economically important varieties such as Shepody and Russet Norkotah due to high levels of mosaic infection. In recent years, an increasing number of NB growers have also imported seed of these varieties because of a perceived problem with the virus quality of NB produced stocks.

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de la Pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

The problem of virus infection of susceptible yet economically important varieties such as Shepody and Russet Norkotah is a serious limitation to the growth of the New Brunswick seed potato industry. Seed becomes down-classed or decertified altogether and is lost prematurely from the seed system. This issue is becoming increasingly important with the development of new seed production areas in Canada (Alberta and Saskatchewan), where virus infection sources are not yet as prevalent. Discussions towards a set of national seed certification standards in the United States indicate interest there to export seed into what are presently Canadian markets.

The financial success of a seed potato grower results in part from a balance between quality and quantity, achieving the greatest possible yield while limiting virus infection and other disease levels. Unfortunately production measures to achieve these two objectives are often different. Lengthening the growing season achieves higher yields but exposes the crop to the vectors of virus spread.

Greensprouting of seed potatoes is a technique used to promote sprout growth prior to planting. The rate of emergence and early plant development are then increased. As a result, tubers are initiated earlier allowing growers to achieve desired yields under a shorter grower season. For the tablestock crop, earlier yields result in higher prices. For the seed crop, earlier yields may result in a better quality crop with less virus infection. For the processing crop (e.g. chipstock), earlier yields may result in higher prices to replace costly imports.

Research conducted at the Bon Accord Elite Seed Potato Centre by Y. Leclerc and D. Wattie in 1997 demonstrated the yield benefit of greensprouting for the production of high-class seed potatoes under a short growing season. Although quality issues were not measured in their work, the technique could possibly impact on seed quality by decreasing the susceptibility of the seed crop to virus infection through a process commonly known as "mature plant resistance".

Current implementation of greensprouting in New Brunswick is limited, with the exception of the production of early tablestock in some areas. This project looks at two other applications of this technique: 1. Seed Potato Production, and 2. Early Chipstock Production.

(This project was initiated and submitted as ARP97024 to the Strategic Partnership Development Fund by the NB Seed Potato Growers' Association with the collaboration of Dr. Yves Leclerc, NBDARD, Wicklow. Lynn Moore and Peter Scott completed the work.)

Materials and Methods

All seed sources, greensprouting facilities, field locations and cultural practices were supplied in 1997 by the grower cooperator for this project, Max van Cingel of Killoween, New Brunswick.

Planting. Seed was greensprouted for approximately 5 weeks using a system of hanging bags. Whole Pre-Elite seed of the varieties Penta, Russet Norkotah and Shepody was used in the seed production trial. Elite III Atlantic seed was greensprouted and then cut prior to planting in the early chipstock trial. Control Atlantic seed was cut and stored until planting. Single row 25 foot plots were planted June 2nd in a randomized complete block design with 4 replicates. This was approximately 10 days later than normal at this location due to a late spring. Control tubers had developed long white sprouts that were not removed. In-row spacing was 7", 9" and 11". Guard plants at the ends of the plot rows were Blue Mac. Guard rows were planted with seed of the same variety. The trial was planted in duplicate for the seed section, to allow for two topkill dates at 70 and 85 days after planting (DAP). The chipstock trial was planted in triplicate to allow for three harvest dates in August. Fertilizer application was based on 85 lbs nitrogen per acre at planting. Oil sprays were applied to the seed production trial six times at approximately 5-day intervals starting in late June. The seed production plots were entered for certification and were therefore rogued as required to meet the Elite I zero virus tolerance. Aphids were not monitored in the seed production blocks.

Emergence and Stem Counts. Emergence counts were taken for all plots 18, 24 and 31 DAP. A final emergence count was made 43 DAP, when the number of stems per plant was also counted for four replicates per greensprouting treatment.

Harvest. Seed plots were topkilled August 11th (70 DAP) and August 26th (85 DAP). All plots from both treatments were harvested September 16th using a single row digger and hand harvesting into bags.

Multiple Atlantic harvests were carried out on August 15th (74 DAP), August 21st (80 DAP) and August 27th (86 DAP). Plants were not topkilled. The tops were pulled by hand and then tubers lifted with a single row digger prior to harvesting by hand.

Grading. Tubers were graded into the following size categories:

1. Penta, Russet Norkotah, Shepody (using metric grading screens): < 28 mm, 28 – 35 mm, 35 – 45 mm, 45 – 55 mm and > 55 mm. Total and 28 – 55 mm yields were calculated. Tubers were counted and weighed per size category.
2. Atlantic: < 1.5", 1.5 – 1.875", 1.875 – 2,0", 2.0 – 2.25", 2.25 – 2.75", 2.75 – 3.0" and > 3.0". Total, marketable (> 1.5" less growth cracks, scab and roughs), 1.5 – 2.0", 1.5 – 2.25" and 1.875 – 2.25" were calculated. Tubers were counted and weighed per size category.

Yield and tuber number data were subjected to analyses using the computer software CoSTAT, for two-way ANOVA randomized complete blocks. Means were separated by Duncan's multiple range test at p = 0.05.

Post-harvest Testing. During grading of the seed plots, duplicate 200 tuber samples were taken for each variety and topkill date. These were taken evenly from all spacings, greensprouting and control treatments, to focus on potential differences caused by topkill date. Samples were submitted to the Agricultural Certification Services laboratory in Fredericton and ELISA sprout tested for the common potato viruses PVY^o and PLRV.

AGTRON chip colour was measured on subsamples from one replicate per treatment the day of or following each Atlantic harvest, to focus on a potential effect caused by greensprouting.

Results

Seed Production.

1. Emergence. Emergence percentages for the three varieties are given in Table 1. When greensprouted, tubers of Penta emerged more quickly than the control. This difference, however, was limited to just a few days and the greensprouted treatments were likely no more than 2 or 3 days earlier to reach 50% emergence. Greensprouting did not clearly effect emergence for Russet Norkotah or Shepody.

2. Stem Counts. There was no difference in number of stems per plant between greensprouted and control treatments for any of the three varieties tested (Table 2). Data were not collected to verify a spacing effect on stem count.

3. Yields. Yields in cwt/acre are given for Penta in Table 3. When measured at the earlier harvest (70 DAP), greensprouting increased the yield of 45 – 55 mm Penta tubers. Variability in the other size categories resulted in no significant yield increase in either total or 28 – 55 mm yields until the later harvest (85 DAP) when greensprouting produced more than the control for both. Spacing had an effect on total, 28 – 55 mm and 35 - 45 mm yields of Penta at the earlier harvest date, but by 85 days total yield was no longer affected. At both harvest dates the effect was predominantly due to increases in the 35 – 45 mm size with the 7" spacing compared with either 9" or 11".

Yield of Russet Norkotah (Table 4) was not affected by greensprouting at either harvest, except for the size category 35 – 45 mm where more was produced at 85 DAP when greensprouted. The narrow spacing of 7" increased total yield and yield of 28 – 55 mm tubers at 70 DAP when compared with both 9" and 11", mostly due to an increase in the yield of 35 – 45 mm tubers. The 7" spacing also produced higher yields of 35 – 45 mm and 28 – 55 mm tubers at the later harvest. Yield of Shepody was not affected by greensprouting in any size category at

Table 1. Percentage emergence measured 18, 24 and 31 days after planting

Variety	Block	Greensprouted			Control		
		18	24	31	18	24	31
Penta	1	47	97	99	10	93	97
	2	36	95	99	5	84	96
	Ave	41.5	96.0	99.0	7.5	88.5	96.5
Russet	1	14	97	99	9	88	97
Norkotah	2	9	96	99	18	95	99
	Ave	11.5	96.5	99.0	13.5	91.5	98.0
Shepody	1	30	84	93	41	93	98
	2	29	82	96	29	83	94
	Ave	29.5	83	94.5	35.0	88.0	96.0

Table 2. Number of stems per plant measured 43 days after planting

Block	Rep *	Penta		Russet Norkotah		Shepody	
		Greensp.	Control	Greensp.	Control	Greensp.	Control
1	1	3.42	3.49	3.27	3.99	3.39	2.94
	3	3.63	3.74	3.32	3.83	3.32	3.60
2	2	4.07	3.01	4.12	3.47	3.33	3.46
	4	3.91	4.10	3.66	3.40	2.83	3.79
Average		3.76	3.58	3.59	3.67	3.22	3.45

* For Shepody replicates 2 and 4 were measured in Block 1 and replicates 1 and 3 were measured in Block 2.

IMPORTANT NOTE CONCERNING THE FOLLOWING PAGES

THE PAGES WHICH FOLLOW HAVE BEEN FILMED TWICE IN ORDER TO OBTAIN THE BEST REPRODUCTIVE QUALITY

USERS SHOULD CONSULT ALL THE PAGES REPRODUCED ON THE FICHE IN ORDER TO OBTAIN A COMPLETE READING OF THE TEXT.

REMARQUE IMPORTANTE CONCERNANT LES PAGES QUI SUIVENT

LES PAGES SUIVANTES ONT ÉTÉ REPRODUITES EN DOUBLE AFIN D'AMÉLIORER LA QUALITÉ DE REPRODUCTION

LES UTILISATEURS DOIVENT CONSULTER TOUTES LES PAGES REPRODUITES SUR LA FICHE AFIN D'OBTENIR LA LECTURE DU TEXTE INTÉGRAL

micromedia
a division of IHS Canada

20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca

Table 3. Greensprouting and spacing effects on yield (cwt/acre) for the potato variety Penta topkilled at 70 and 85 days

			70 day topkill			
Size	C.V.*	Treatment			Spacing	
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
< 28		0.85	1.23	1.12	0.88	1.12
28 – 35	30.25	4.15	6.76	5.51	5.51	5.35
35 – 45	16.81	65.0 a	64.3 a	80.6 a	56.1 b	57.1 b
45 – 55	18.57	62.3 a	48.7 b	55.7 a	54.4 a	56.4 a
> 55	43.40	19.0	17.4	17.4	16.9	20.2
Total	12.64	151.2 a	138.3 a	160.3 a	133.8 b	140.1 b
28 – 55	14.06	131.4 a	119.7 a	141.8 a	116.0 b	118.8 b
			85 day topkill			
Size	C.V.	Treatment			Spacing	
(in mm)		Greenspr.	Control	7"	9"	11"
< 28		0.9	1.0	1.0	1.0	0.8
28 – 35	33.38	4.4	4.9	5.1	4.1	4.7
35 – 45	17.63	56.1 a	48.6 a	63.6 a	52.0 b	41.4 c
45 – 55	22.26	99.5	78.8	92.5	89.4	85.6
> 55	23.95	74.7	75.2	64.7	76.8	83.4
Total	10.40	235.5 a	208.6 b	227.0 a	223.3 a	215.9 a
28 – 55	17.25	159.9 a	132.4 b	161.2 a	145.5 ab	131.7 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 4. Greensprouting and spacing effects on yield (cwt/acre) for the potato variety Russet Norkotah topkilled at 70 and 85 days

			70 day topkill			
Size	C.V.*	Treatment			Spacing	
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
< 28		1.28	1.86	2.23	1.12	1.36
28 – 35	26.10	8.0	11.2	12.4	8.1	8.4
35 – 45	15.40	80.8 a	81.4 a	92.9 a	76.7 b	73.7 b
45 – 55	23.83	22.8	22.3	21.9	24.6	21.1
> 55	127.61	1.38	1.86	0.72	1.68	2.48
Total	12.11	114.4 a	118.5 a	130.1 a	112.1 b	107.1 b
28 – 55	12.32	111.7 a	114.8 a	127.1 a	109.3 b	103.3 b
			85 day topkill			
Size	C.V.	Treatment			Spacing	
(in mm)		Greenspr.	Control	7"	9"	11"
< 28		1.28	1.01	1.28	1.20	0.96
28 – 35	33.84	5.6	6.2	6.4	5.9	5.4
35 – 45	14.03	92.6 a	81.3 b	100.5 a	83.7 b	76.7 b
45 – 55	17.98	88.8 a	86.2 a	87.4 a	89.1 a	85.8 a
> 55	39.49	18.8	24.9	18.0	20.7	26.8
Total	10.92	207.0 a	199.6 a	213.6 a	200.6 a	195.7 a
28 – 55	11.22	186.9 a	173.7 a	194.3 a	178.7 ab	167.9 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 3. Greensprouting and spacing effects on yield (cwt/acre) for the potato variety Penta topkilled at 70 and 85 days

70 day topkill						
Size	C.V.*	Treatment			Spacing	
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
< 28		0.85	1.23	1.12	0.88	1.12
28 – 35	30.25	4.15	6.76	5.51	5.51	5.35
35 – 45	16.81	65.0 a	64.3 a	80.6 a	56.1 b	57.1 b
45 – 55	18.57	62.3 a	48.7 b	55.7 a	54.4 a	56.4 a
> 55	43.40	19.0	17.4	17.4	16.9	20.2
Total	12.64	151.2 a	138.3 a	160.3 a	133.8 b	140.1 b
28 – 55	14.06	131.4 a	119.7 a	141.8 a	116.0 b	118.8 b
85 day topkill						
Size	C.V.	Treatment			Spacing	
(in mm)		Greenspr.	Control	7"	9"	11"
< 28		0.9	1.0	1.0	1.0	0.8
28 – 35	33.38	4.4	4.9	5.1	4.1	4.7
35 – 45	17.63	56.1 a	48.6 a	63.6 a	52.0 b	41.4 c
45 – 55	22.26	99.5	78.8	92.5	89.4	85.6
> 55	23.95	74.7	75.2	64.7	76.8	83.4
Total	10.40	235.5 a	208.6 b	227.0 a	223.3 a	215.9 a
28 – 55	17.25	159.9 a	132.4 b	161.2 a	145.5 ab	131.7 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 4. Greensprouting and spacing effects on yield (cwt/acre) for the potato variety Russet Norkotah topkilled at 70 and 85 days

70 day topkill						
Size	C.V.*	Treatment			Spacing	
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
< 28		1.28	1.86	2.23	1.12	1.36
28 – 35	26.10	8.0	11.2	12.4	8.1	8.4
35 – 45	15.40	80.8 a	81.4 a	92.9 a	76.7 b	73.7 b
45 – 55	23.83	22.8	22.3	21.9	24.6	21.1
> 55	127.61	1.38	1.86	0.72	1.68	2.48
Total	12.11	114.4 a	118.5 a	130.1 a	112.1 b	107.1 b
28 – 55	12.32	111.7 a	114.8 a	127.1 a	109.3 b	103.3 b
85 day topkill						
Size	C.V.	Treatment			Spacing	
(in mm)		Greenspr.	Control	7"	9"	11"
< 28		1.28	1.01	1.28	1.20	0.96
28 – 35	33.84	5.6	6.2	6.4	5.9	5.4
35 – 45	14.03	92.6 a	81.3 b	100.5 a	83.7 b	76.7 b
45 – 55	17.98	88.8 a	86.2 a	87.4 a	89.1 a	85.8 a
> 55	39.49	18.8	24.9	18.0	20.7	26.8
Total	10.92	207.0 a	199.6 a	213.6 a	200.6 a	195.7 a
28 – 55	11.22	186.9 a	173.7 a	194.3 a	178.7 ab	167.9 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

either harvest date (Table 5). Spacing had a significant effect on yield of 28 – 55 mm tubers only at the 85 day topkill date, where 7" produced more than either 9" or 11".

4. Tuber number. With the variety Penta (Table 6), greensprouting increased number of 45 – 55 mm tubers but did not affect either total or 28 – 55 mm numbers at 70 days. At this earlier harvest, significantly more tubers were produced at 7" for the 28 – 55 mm size category, mostly due to an increase in 35 – 45 mm numbers. By the 85 day harvest, greensprouting had significantly increased both total and 28 – 55 mm tuber numbers. A 7" spacing and 85 day harvest produced more 35 – 45 mm tubers than either the 9" or 11" spacings, and also more total and 28 – 55 mm tubers than the 11" spacing.

With the variety Russet Norkotah, greensprouting decreased the total tuber number at 70 days but had no effect by the 85 day harvest (Table 7). The 7" spacing produced more tubers than either 9" or 11" in all size categories except for 45 – 55 mm and > 55 mm. At 85 days the 7" spacing still produced significantly more tubers than the other two spacings for 35 – 45 mm, but only produced significantly more tubers than 11" for total and 28 – 55 mm.

With the variety Shepody, greensprouting did not affect tuber numbers when topkilled at either 70 or 85 DAP (Table 8). The 7" spacing produced more total and 28 – 55 mm tubers than either 9" or 11" at both harvests.

5. Virus Infection. Levels of the common potato viruses PVY^o and PLRV are given in Table 9 for samples taken from all three varieties and both topkill dates. During the past few years there has been very little leafroll infection in seed potatoes grown in New Brunswick, and the potato leafroll virus was only detected in one of 12 samples from this trial. The common strain of potato virus Y (PVY^o) is much more prevalent. Delaying topkill for two weeks resulted in an increase in PVY^o infection for both Penta and Russet Norkotah. In the latter case the infection level almost doubled, from an average of 4% to almost 8%. Virus level in Shepody did not appear affected by the topkill delay. Shepody was severely infected (4.75%) by 70 DAP and this level did not increase.

Early Chipstock Production.

1. Emergence. Emergence percentages for Atlantic are given in Table 10. The greensprouted treatments emerged slightly ahead of the controls, but this was limited to a few days.

2. Stem Count. There was no significant difference in stems/plant between the greensprouted and control plants that averaged 2.91 and 3.01 stems per plant respectively.

Table 5. Greensprouting and spacing effects on yield (cwt/acre) for the potato variety Shepody topkilled at 70 and 85 days

70 day topkill						
Size	C.V.*	Treatment		Spacing		
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
<28		0.85	1.01	0.81	0.80	0.72
28 – 35	28.89	4.8	4.5	6.9	3.4	3.6
35 – 45	26.53	49.8	55.3	63.2	47.2	47.2
45 – 55	28.06	54.9	55.3	55.5	55.9	54.0
>55	50.29	24.7	24.4	21.0	26.9	25.6
Total	15.96	135.0 a	140.4 a	147.9 a	134.2 a	131.1 a
28 – 55	20.10	109.5 a	115.1 a	125.6 a	106.5 a	104.8 a
85 day topkill						
Size	C.V.	Treatment		Spacing		
(in mm)		Greenspr.	Control	7"	9"	11"
<28		1.01	1.17	1.36	1.04	0.88
28 – 35	34.64	2.9	4.1	4.2	3.2	3.1
35 – 45	23.37	48.9	50.6	61.2	46.6	41.6
45 – 55	22.27	74.7	69.7	81.5	69.1	66.0
>55	23.97	83.7	76.7	66.4	78.2	96.1
Total	7.91	211.3 a	202.3 a	214.6 a	198.1 a	207.7 a
28 – 55	17.46	126.6 a	124.4 a	146.9 a	118.8 b	110.8 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 6. Greensprouting and spacing effects on tuber numbers (per plot) for the potato variety Penta topkilled at 70 and 85 days

70 day topkill						
Size	C.V.*	Treatment		Spacing		
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
<28	58.4	7	14	11	8	13
28 – 35	30.7	16	26	22	21	21
35 – 45	17.9	114 a	116 a	146 a	98 b	101 b
45 – 55	19.2	67 a	52 b	60 a	58 a	61 a
>55	39.1	13	12	12	12	14
Total	13.2	218 a	221 a	252 a	197 b	209 a
28 – 55	14.1	198 a	194 a	228 a	177 b	182 b
85 day topkill						
Size	C.V.	Treatment		Spacing		
(in mm)		Greenspr.	Control	7"	9"	11"
<28	61.8	8	10	9	8	10
28 – 35	35.7	17	19	20	16	18
35 – 45	15.4	97 a	86 a	112 a	90 b	72 c
45 – 55	24.5	97	77	90	89	83
>55	24.2	46	44	39	47	48
Total	11.4	265 a	236 b	270 a	250 ab	231 b
28 – 55	15.9	211 a	182 b	221 a	195 ab	173 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 7. Greensprouting and spacing effects on tuber numbers (per plot) for the potato variety Russet Norkotah topkilled at 70 and 85 days

70 day topkill						
Size (in mm)	C.V.* (%)	Treatment Greenspr.	 Control	Spacing 7"	 9"	 11"
<28	38.65	12	16	19	10	12
28 – 35	25.25	26	34	39	25	25
35 – 45	15.48	112 a	118 a	136 a	108 b	101 b
45 – 55	24.77	18	18	18	20	16
>55	127.3	1	1	<1	1	1
Total	11.92	168 b	187 a	212 a	164 b	156 b
28 – 55	11.90	156 a	170 a	193 a	153 b	143 b
85 day topkill						
Size (in mm)	C.V.	Treatment Greenspr.	 Control	Spacing 7"	 9"	 11"
<28	55.43	11	9	13	10	7
28 – 35	30.13	18	20	22	19	17
35 – 45	14.78	119 a	108 a	133 a	110 b	97 b
45 – 55	17.86	66 a	61 a	63 a	66 a	61 a
>55	41.26	8	11	7	10	12
Total	11.15	221 a	210 a	238 a	214 ab	194 b
28 – 55	11.71	202 a	190 a	218 a	194 ab	175 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 8. Greensprouting and spacing effects on tuber numbers (per plot) for the potato variety Shepody topkilled at 70 and 85 days

70 day topkill						
Size (in mm)	C.V.* (%)	Treatment Greenspr.	 Control	Spacing 7"	 9"	 11"
<28	55.3	7	10	12	8	7
28 – 35	34.25	15	14	21	11	11
35 – 45	24.9	66	73	85	62	62
45 – 55	27.4	40	40	42	40	39
>55	51.87	11	11	10	12	11
Total	16.77	139 a	149 a	169 a	132 b	130 b
28 – 55	18.72	121 a	127 a	148 a	112 b	112 b
85 day topkill						
Size (in mm)	C.V.	Treatment Greenspr.	 Control	Spacing 7"	 9"	 11"
<28	51.92	8	9	12	8	6
28 – 35	34.91	9	13	13	10	10
35 – 45	22.1	61	64	77	60	50
45 – 55	19.94	52 a	50 a	58 a	50 ab	44 b
>55	25.57	34	30	27	33	36
Total	11.23	164 a	165 a	187 a	160 b	147 b
28 – 55	15.93	122 a	126 a	148 a	119 b	104 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 5. Greensprouting and spacing effects on yield (cwt/acre) for the potato variety Shepody topkilled at 70 and 85 days

		70 day topkill				
Size	C.V.*	Treatment		Spacing		
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
< 28		0.85	1.01	0.81	0.80	0.72
28 – 35	28.89	4.8	4.5	6.9	3.4	3.6
35 – 45	26.53	49.8	55.3	63.2	47.2	47.2
45 – 55	28.06	54.9	55.3	55.5	55.9	54.0
> 55	50.29	24.7	24.4	21.0	26.9	25.6
Total	15.96	135.0 a	140.4 a	147.9 a	134.2 a	131.1 a
28 – 55	20.10	109.5 a	115.1 a	125.6 a	106.5 a	104.8 a
		85 day topkill				
Size	C.V.	Treatment		Spacing		
(in mm)		Greenspr.	Control	7"	9"	11"
< 28		1.01	1.17	1.36	1.04	0.88
28 – 35	34.64	2.9	4.1	4.2	3.2	3.1
35 – 45	23.37	48.9	50.6	61.2	46.6	41.6
45 – 55	22.27	74.7	69.7	81.5	69.1	66.0
> 55	23.97	83.7	76.7	66.4	78.2	96.1
Total	7.91	211.3 a	202.3 a	214.6 a	198.1 a	207.7 a
28 – 55	17.46	126.6 a	124.4 a	146.9 a	118.8 b	110.8 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 6. Greensprouting and spacing effects on tuber numbers (per plot) for the potato variety Penta topkilled at 70 and 85 days

		70 day topkill				
Size	C.V.*	Treatment		Spacing		
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
< 28	58.4	7	14	11	8	13
28 – 35	30.7	16	26	22	21	21
35 – 45	17.9	114 a	116 a	146 a	98 b	101 b
45 – 55	19.2	67 a	52 b	60 a	58 a	61 a
> 55	39.1	13	12	12	12	14
Total	13.2	218 a	221 a	252 a	197 b	209 a
28 – 55	14.1	198 a	194 a	228 a	177 b	182 b
		85 day topkill				
Size	C.V.	Treatment		Spacing		
(in mm)		Greenspr.	Control	7"	9"	11"
< 28	61.8	8	10	9	8	10
28 – 35	35.7	17	19	20	16	18
35 – 45	15.4	97 a	86 a	112 a	90 b	72 c
45 – 55	24.5	97	77	90	89	83
> 55	24.2	46	44	39	47	48
Total	11.4	265 a	236 b	270 a	250 ab	231 b
28 – 55	15.9	211 a	182 b	221 a	195 ab	173 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 7. Greensprouting and spacing effects on tuber numbers (per plot) for the potato variety Russet Norkotah topkilled at 70 and 85 days

70 day topkill						
Size	C.V.*	Treatment			Spacing	
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
< 28	38.65	12	16	19	10	12
28 – 35	25.25	26	34	39	25	25
35 – 45	15.48	112 a	118 a	136 a	108 b	101 b
45 – 55	24.77	18	18	18	20	16
> 55	127.3	1	1	<1	1	1
Total	11.92	168 b	187 a	212 a	164 b	156 b
28 – 55	11.90	156 a	170 a	193 a	153 b	143 b
85 day topkill						
Size	C.V.	Treatment			Spacing	
(in mm)		Greenspr.	Control	7"	9"	11"
< 28	55.43	11	9	13	10	7
28 – 35	30.13	18	20	22	19	17
35 – 45	14.78	119 a	108 a	133 a	110 b	97 b
45 – 55	17.86	66 a	61 a	63 a	66 a	61 a
> 55	41.26	8	11	7	10	12
Total	11.15	221 a	210 a	238 a	214 ab	194 b
28 – 55	11.71	202 a	190 a	218 a	194 ab	175 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, $p = 0.05$.

Table 8. Greensprouting and spacing effects on tuber numbers (per plot) for the potato variety Shepody topkilled at 70 and 85 days

70 day topkill						
Size	C.V.*	Treatment			Spacing	
(in mm)	(%)	Greenspr.	Control	7"	9"	11"
< 28	55.3	7	10	12	8	7
28 – 35	34.25	15	14	21	11	11
35 – 45	24.9	66	73	85	62	62
45 – 55	27.4	40	40	42	40	39
> 55	51.87	11	11	10	12	11
Total	16.77	139 a	149 a	169 a	132 b	130 b
28 – 55	18.72	121 a	127 a	148 a	112 b	112 b
85 day topkill						
Size	C.V.	Treatment			Spacing	
(in mm)		Greenspr.	Control	7"	9"	11"
< 28	51.92	8	9	12	8	6
28 – 35	34.91	9	13	13	10	10
35 – 45	22.1	61	64	77	60	50
45 – 55	19.94	52 a	50 a	58 a	50 ab	44 b
> 55	25.57	34	30	27	33	36
Total	11.23	164 a	165 a	187 a	160 b	147 b
28 – 55	15.93	122 a	126 a	148 a	119 b	104 b

* For data with a coefficient of variance (C.V.) of less than 20.0, values within greensprouting treatment or spacing followed by different letters differ significantly using Duncan's multiple range test, $p = 0.05$.

Table 9. Percentage virus infection following topkill application at 70 and 85 days after planting for three potato varieties (n = 187 – 202)

Variety	*Sample*	*70 DAP*		*85 DAP*	
		PVY^{o}	PLRV	PVY^{o}	PLRV
Penta	1	0	0	1.1	0
	2	0	0	0.5	0
	Ave	0	0	0.8	0
Russet Norkotah	1	6.4	0	6.4	0
	2	1.5	1.04	8.9	0
	Ave	3.95	0.52	7.65	0
Shepody	1	5.5	0	6.5	0
	2	4.0	0	3.1	0
	Ave	4.75	0	4.8	0

Table 10. Percentage emergence for Atlantic 18, 24 and 31 days after planting

Block	Greensprouted			Control		
	18	24	31	18	24	31
1	69	96	98	36	91	97
2	79	95	99	62	87	98
3	71	96	98	38	94	97
Ave	73	96	98	45	91	97

3. Yield. The Atlantic yield data is given in Table 11. Greensprouting caused a yield increase of approximately 10 cwt/acre for both total and marketable yield although this effect was not significant at any of the three harvest dates. There were also no significant yield differences due to greensprouting in any of the tuber size categories (data not shown). The 7" spacing produced significantly greater total and marketable yields than the 11" spacing at the first two harvests only. Very few significant differences existed in the size categories: 7" spacing produced more than either 9" or 11" for 1.5–2" (74 DAP); 1.5–2.25" (74 and 86 DAP) and 1.875–2.25" (74 and 86 DAP) (data not shown).

4. Tuber number. The number of tubers per plot was not affected by greensprouting (Table 12). This is consistent with the lack of effect on stems per plant caused by greensprouting reported above in subsection 2. Tuber number was affected by spacing, however not as much as would have been expected by planting density alone, due to a positive effect on set by spacing. Tubers/plant were as follows: 7" = 5.5 c; 9" = 6.1 b; and 11" = 7.2 a. Set was not affected by greensprouting = 6.3; control = 6.4.

Table 9. Percentage virus infection following topkill application at 70 and 85 days after planting for three potato varieties (n = 187 – 202)

Variety	*Sample*	*70 DAP*		*85 DAP*	
		PVY°	PLRV	PVY°	PLRV
Penta	1	0	0	1.1	0
	2	0	0	0.5	0
	Ave	0	0	0.8	0
Russet Norkotah	1	6.4	0	6.4	0
	2	1.5	1.04	8.9	0
	Ave	3.95	0.52	7.65	0
Shepody	1	5.5	0	6.5	0
	2	4.0	0	3.1	0
	Ave	4.75	0	4.8	0

Table 10. Percentage emergence for Atlantic 18, 24 and 31 days after planting

Block	Greensprouted			Control		
	18	24	31	18	24	31
1	69	96	98	36	91	97
2	79	95	99	62	87	98
3	71	96	98	38	94	97
Ave	73	96	98	45	91	97

3. Yield. The Atlantic yield data is given in Table 11. Greensprouting caused a yield increase of approximately 10 cwt/acre for both total and marketable yield although this effect was not significant at any of the three harvest dates. There were also no significant yield differences due to greensprouting in any of the tuber size categories (data not shown). The 7" spacing produced significantly greater total and marketable yields than the 11" spacing at the first two harvests only. Very few significant differences existed in the size categories: 7" spacing produced more than either 9" or 11" for 1.5–2" (74 DAP); 1.5–2.25" (74 and 86 DAP) and 1.875–2.25" (74 and 86 DAP) (data not shown).

4. Tuber number. The number of tubers per plot was not affected by greensprouting (Table 12). This is consistent with the lack of effect on stems per plant caused by greensprouting reported above in subsection 2. Tuber number was affected by spacing, however not as much as would have been expected by planting density alone, due to a positive effect on set by spacing. Tubers/plant were as follows: 7" = 5.5 c; 9" = 6.1 b; and 11" = 7.2 a. Set was not affected by greensprouting = 6.3; control = 6.4.

Table 11. Greensprouting and spacing effects on yield (cwt/acre) for the potato variety Atlantic at three harvest dates

Block # Harvest date	Yield*	C.V. **	Treatment		Spacing		
			Green-sprouted	Control	7"	9"	11"
1 (74 dap)	Total	9.05	180.7 a	169.5 a	188.7 a	173.4 ab	163.2 b
Aug. 15th	Marketable	9.48	172.5 a	162.2 a	181.6 a	164.0 ab	156.3 b
2 (80 dap)	Total	14.35	245.7 a	234.5 a	253.9 a	252.3 a	213.9 b
Aug. 21st	Marketable	15.16	231.6 a	221.9 a	239.7 a	240.2 a	200.4 b
3 (86 dap)	Total	8.21	278.1 a	267.8 a	281.1 a	269.4 a	268.4 a
Aug. 27th	Marketable	8.76	256.1 a	255.6 a	268.9 a	251.8 a	246.9 a

* Marketable yield is > 1.5" less growth cracks, scab and roughs.

** For data with a coefficient of variance (C.V.) of less than 20.0, treatment and spacing values at each harvest followed by different letters differ significantly using Duncan's multiple range test, $p = 0.05$.

Table 12. Greensprouting and spacing effects on tuber numbers (per plot) for the potato variety Atlantic at three harvest dates

Block # Harvest date	Yield	Treatment		Spacing		
		Green-sprouted	Control	7"	9"	11"
1 (74 dap)	Total	197	194	211	195	180
Aug. 15th	Marketable	170	165	183	163	154
2 (80 dap)	Total	199	210	223	203	188
Aug. 21st	Marketable	178	177	186	180	167
3 (86 dap)	Total	201	202	228	196	182
Aug. 27th	Marketable	176	182	193	177	168

5. Specific Gravity. Specific gravity of Atlantic was not affected by either greensprouting or spacing in this trial and averaged 1.0932 (Table 13).

6. Chip Colour. In order to be acceptable to Humpty Dumpty, Agtron values for chip colour should be 60 or greater as specified by contract. Depending on supply, values of 58 may sometimes be accepted. On this basis, at the first harvest, only the greensprouted treatment spaced at 7" produced potatoes that would have been accepted for potato chips (Table 14). By the second harvest greensprouting had little effect on colour, and all but the 9" spacing produced an acceptable product. All values were unacceptable at the third harvest.

Table 13. Greensprouting and spacing effects on specific gravity for the potato variety Atlantic at three harvest dates

Harvest	C.V.	Treatment		Spacing		
		Green-sprouted	Control	7"	9"	11"
1 (74 dap) Aug. 15th	0.70	1.0971 a	1.100 a	1.0979 a	1.0985 a	1.0992a
2 (80 dap) Aug. 21st	0.26	1.0914 a	1.0907 a	1.0923 a	1.0910 a	1.0899 a
3 (86 dap) Aug. 27th	0.19	1.0903 a	1.0990 a	1.0899 a	1.0892 a	1.0912 a

* For data with a coefficient of variance (C.V.) of less than 20.0, treatment and spacing values at each harvest followed by different letters differ significantly using Duncan's multiple range test, p = 0.05.

Table 14. Agtron values measured for Atlantic chip samples taken at harvest

Treatment	Spacing	Harvest date		
		August 15	August 21	August 27
Greensprouted	7"	60.4	63.5 & 63.2	51.2
	9"	58.2	58.2 & 58.7	47.0
	11"	56.2	63.3 & 63.8	56.9
Control	7"	57.8	63.4 & 64.6	51.7
	9"	57.8	59.7 & 56.9	48.7
	11"	57.1	63.8 & 62.7	50.6

Discussion

Seed Production. One of the generally accepted advantages of greensprouting is more rapid emergence followed by earlier crop development and increased yields. This was generally not observed in this trial, where planting had been delayed approximately 10 days due to a late spring. By then the control seed pieces had developed white sprouts. The plots were hand-planted and these sprouts were not removed by the planting operation. This likely allowed the control tubers to emerge almost as rapidly as the greensprouted tubers. More rapid emergence was only noted for greensprouted Penta and the difference was limited to a few days (Table 1). This did not translate into increased early yields although greensprouted yields were greater by the second topkill, 85 DAP (Table 3). However by then virus infection had occurred. There was only a slight increase in number of stems/plant for Penta with greensprouting (Table 2). More stems generally means more tubers, which is desirable for seed production, but this effect was also not noted for Penta until the second harvest (Table 6).

In this trial Russet Norkotah and Shepody showed little benefit due to greensprouting. There was no clear emergence difference (Table 1) or an increase in stem counts for greensprouted versus control treatments (Table 2). There were also few yield benefits detected for these varieties (Tables 4 & 5), and seed quality was negatively affected by delaying topkilling in August for Russet Norkotah (Table 9).

In this trial, both Penta and Russet Norkotah produced more at 7" than either 9" or 11". The differences between 9" and then 11" were not significant. It is difficult to achieve such a narrow spacing but this trial indicates a benefit from the effort. Approximately 7 cwt/acre more seed are required to plant at 7" instead of 9". For Penta, this closer spacing produced a seed yield increase of 15 - 25 cwt/acre for a net profit of 8 - 18 cwt/acre depending on harvest date (Table 3). A similar benefit was observed with Russet Norkotah, especially at the earlier topkill date (Table 4).

Early topkill is one of the standard management practices to limit virus infection in a seed potato crop. However for both Russet Norkotah and Shepody in this trial, a topkill date of August 11th was not sufficient to produce a crop with low virus readings (Table 9). Either spread had occurred into the plots prior to August 11th, or roguing had missed the mild mosaic symptoms often associated with these two varieties, allowing it to further spread unnoticed. The use of oil sprays in this trial, while it may have limited virus spread was also not sufficient to produce a clean crop.

Chipstock Production. Greensprouting of Atlantic under the conditions of this trial did not greatly promote emergence. The effect was limited to a few days (Table 10) and this did not translate into yield differences at any of the three harvest dates (Table 11). Greensprouting also did not affect the number of stems per plant or tubers per plant. This lack of effect was most likely caused by the delay in planting such that the controls were by then also well sprouted. Hand planting did not remove the white sprouts that had developed on the controls. Greensprouting also had no effect on specific gravity (Table 13) and only positively affected chip colour at the earliest harvest at the closest (7") spacing (Table 14). The earliest harvest in this trial, although at 74 days after planting, did not take place until mid August. To be considered very early, delivery of chipstock to the plant should take place in late July, when with a contract, a producer could expect to receive a premium of about $0.40/cwt above a basic price of $10.85/cwt (1997). On the open market prices might be $16 or even $19/cwt in late July. Such an early harvest was not considered reasonable with this year's later planting date. Given that chip colour was barely acceptable in mid August, it is unlikely that an even earlier Atlantic harvest in 1997 would have produced an acceptable product.

Spacing at 7" significantly increased total and marketable yield at the first two harvests, when compared with 11" (Table 11). There was no difference when compared with 9", and differences with specific size categories were not consistent across the harvests. An increase in tuber numbers (Table 12) at the closer spacings resulted in this yield increase. This tuber number increase was less pronounced than would have been expected due to spacing alone due to a positive effect by spacing on set. The wider the spacing, the greater the number of tubers per plant produced.

Decreasing spacing from 11" to 7" requires an additional 11 cwt/acre of seed. This produced an increase in marketable yield of at least 22 cwt/acre. Based on a seed cost of $10/cwt and a chipstock contract price of $10.85/cwt, the benefit of this reduced spacing is then approximately $125/acre.

When Atlantic is grown for seed, these results indicate that a very narrow spacing is somewhat less critical than for Penta or Russet Norkotah. Although some of the smaller sizes benefited from the 7" spacing at one or two of the three harvests, there was no significant yield difference when spacing was increased from 7" to 9", as long as it did not reach 11" (Table 11).

Conclusion

The 1997 growing season did not allow for a representative evaluation of the potential benefits of greensprouting Atlantic for early chipstock production or Penta, Russet Norkotah and Shepody for seed production.

With the varieties Penta, Russet Norkotah, Shepody and Atlantic, there is a yield benefit to reducing in-row spacing from 11" to 7" for the production of seed or chipstock. The financial benefit of this reduced spacing will vary with seed and chipstock prices.

Acknowledgements

The author wishes to thank Max van Cingel for providing the seed, seed preparation, land and general crop maintenance. Peter Scott (NBDARD), Janet McLaughlin (NBDARD) and Nicole Kilfoil (summer student, Wicklow office) are thanked for their technical assistance. Partial funding for this project was supplied by the Strategic Partnership Development Fund under ARP97024.

EARLY POTATO VARIETY DEVELOPMENT - SPUDTECH 1999

MISE AU POINT DE VARIÉTÉS DE POMMES DE TERRE HÂTIVES - SPUDTECH 1999

Lynn M. Moore[1]

Partner / Partenaire: New Brunswick Potato Agency / L'Agence de la pomme de terre du Nouveau-Brunswick

Abstract: A total of 36 new potato varieties were planted in an early tablestock trial at Whites Cove, NB and compared with 6 control varieties as greensprouted, cut seed and demonstration sections. Data was collected regarding yields, tuber numbers and skinning in the greensprouted and cut seed sections. In the greensprouted section, AC Ptargmigan, CalWhite and Quaggy Joe again showed promise against Eramosa, and Envol matched Jemseg at 79 days from planting. Both Adora and F80054 yielded well for yellows. Of the red-skinned varieties, ND 3574-5R matched the control Dark Red Norland as both greensprouted and cut seed. NorDonna was a disappointment in both sections. Of the new yellow fleshed varieties tested as cut seed, only Columbo significantly yielded better than Yukon Gold, although Eloge, Maranca and OAC Ruby Gold showed promise. Total glycoalkyloid levels were measured for ND3574-5R, All Blue, All Red and check Superior. All fell within acceptable limits. A demonstration using NYL235-4, did not show any Colorado potato beetle resistance offered by this selection's trichomes. Longlac produced an extremely uniform set of marketable tubers. Seed of some varieties was produced at the NB Horticulture Centre at Hoyt. Using trickle irrigation seed yields varied from 277 cwt/acre to 529 cwt/acre. Information collected will be used by growers of the SE New Brunswick Horticulture Association to decide upon trial details for 2000.

Résumé : Trente-six nouvelles variétés de pommes de terre de table hâtives ont été plantées à Whites Cove (N.-B.) pour les comparer à six variétés témoins. L'essai était divisé en trois sections : semences prégermées, semences coupées et section de démonstration. Les données recueillies portaient sur les rendements, le nombre de tubercules et la formation de la peau dans les sections des semences prégermées et des semences coupées. Dans la section des semences prégermées, AC Ptarmigan, CalWhite et Quaggy Joe se sont révélées prometteuses comparées avec Eramosa, et Envol équivalait à Jemseg 79 jours après la plantation. Chez les variétés à chair jaune, Adora et F80054 ont eu un bon rendement. Chez les variétés à peau rouge, ND 3574-5R était équivalente à Dark Red Norland dans les sections des semences prégermées et des semences coupées. NorDonna a déçu dans les deux sections. De toutes les nouvelles variétés à chair jaune mises à l'essai comme semences coupées, seule Columbo a donné un rendement bien meilleur que Yukon Gold, mais Eloge, Maranca et OAC Ruby Gold semblent prometteuses. La teneur en glyco-alkaloïdes a été mesurée pour ND3574-5R, All Blue, All Red et Superior. Toutes étaient dans les limites acceptables. Une démonstration réalisée avec NYL235-4 n'a pas révélé de résistance au doryphore de la pomme de terre offerte par les trichomes de cette variété. Longlac a produit un lot très uniforme de tubercules commercialisables. Les semences de certaines variétés ont été produites au Centre horticole du N.-B. à Hoyt. Avec l'irrigation goutte-à-goutte, les rendements de semences variaient de 277 à 529 quintaux l'acre. Les données recueillies seront utilisées par les producteurs membres de l'Association horticole du Sud-Est du Nouveau-Brunswick pour établir les modalités des essais qui seront réalisés en 2000.

Introduction

Each year, market garden farmers in the Fredericton/Grand Lake/Jemseg area eagerly await their first sales of new potatoes. Consumers often make their first visit of the season to local market stands in search of these new potatoes.

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

At the request of the potato producers of the South-Eastern New Brunswick Horticulture Association, a project was submitted in 1999 by the NB Potato Agency to evaluate a number of new or promising potato varieties for their adaptation to early tablestock production. Varieties included round whites, yellow fleshed, red or other coloured or russetted skins and various combinations of these. They were predominantly public releases with no limitations on their distribution. In year two, some public varieties were included for a second year and more varieties protected by Plant Breeder's Rights were also included. Varieties for specific "niche" markets were chosen for a demonstration section.

A number of varieties which are not yet otherwise available locally were produced under this project as seed to ensure that seed stocks be available for further evaluation in 2000.

Materials and Methods

Variety Trials.

1. Seed Sources and Preparation. Seed from a total of 42 tablestock potato varieties was accessed from: Bon Accord Elite Seed Potato Centre; NB Horticulture Centre (ARP98018); private seed growers in New Brunswick, Quebec, Ontario, Alberta and Maine; and the AAFC Breeding Substation at Benton Ridge. Seed class varied from Pre-Elite through to Certified. A total of twenty-six varieties (including 6 checks) were trialed in two replicated block designs. Two-thirds of these varieties are protected by Plant Breeders' Rights and are represented by seven different companies, grower associations or breeders. Sixteen public varieties (including two checks) were planted as single plots for demonstration purposes.

Sixteen varieties were included in a greensprouted section : AC Ptarmigan, Adora, CalWhite, Dark Red Norland, F80054, Envol, Eramosa, Goldrush, Jemseg, ND3574-5R, NorDonna, Norgold Russet, Quaggy Joe, OAC Ruby Gold, OAC Temagami and Yukon Gold, plus "spacer" Caribe. Depending on its availability, seed was placed one to two layers deep in plastic trays March 24th - April 7th . Tubers were then greensprouted for 3 – 5 weeks in a greenhouse at the NB Horticulture Centre, Hoyt, prior to planting on April 28th. Although 2 oz. whole seed was desired, in some varieties enough smalls were not available and size varied up to 3 or even 4 oz (especially Adora and Jemseg). For AC Ptarmigan and Envol some of the larger tubers were cut in half through the bud end.

Nineteen varieties were included in a cut seed section : Appell, Coastal Russet, Columbo, Dark Red Norland, Eloge, Goldrush, Maranca, Matilda, Miriam, Morning Gold, ND 3574-5R, NorDonna, Norgold Russet, OAC Ruby Gold, OAC Temagami, Penta, Quaggy Joe, Superior and Yukon Gold, plus "spacer" Caribe. These were cut and then held in the grading area of the NBHC under plastic for 8 days prior to planting. As much as possible 4 oz tubers were cut in half. Some Matilda were cut into 3 or even 4 pieces, some Eloge into 3 and Morning Gold tubers were generally larger than 4 oz to start with. A few whole seed of Maranca and Miriam were used. No seed piece treatment was applied.

Sixteen varieties were included in the demonstration section: AC Blue Pride, AC Domino, All Blue, All Red, Banana, Blue Mac, Caribe, Longlac, NYL235-4 ("Prince Hairy"), OAC Royal Gold, Purple Chief, Purple Viking, River John Blue, Russian Blue, Skerry Blue and Superior. Depending on size, seed was planted whole or cut into 2 or more pieces. Tubers of the varieties Caribe, Quaggy Joe, OAC Temagami or NorDonna were used as "spacer" plants.

2. Planting. Varieties were planted in three different blocks. The greensprouted varieties were planted in a replicated block design with 4 replicates on April 28th. The cut seed varieties were planted in a replicated block design with 4 replicates on May 12th. Most of the demonstration varieties were planted in single plots May 12th The remainder, All Blue, Purple Viking and Banana, were planted May 27th

Following row opening, varieties in the greensprouted and cut seed sections were planted at 9" in-row spacing, 10 plants per row and 3 rows per plot. Varieties in the demonstration section were also planted 3 rows per plot, at 9" in-row spacing except for Purple Chief, Blue Mac and AC Domino which were planted at 14". Rows of the demonstration varieties varied from 7 to 15 plants depending on the amount of seed available. Four "spacer" plants of a visibly different variety were planted per row between varieties for ease of harvest.

Fertilizer application at row-opening was 85 lbs N/acre using 10-10-10.

3. Crop maintenance. Sencor was applied pre-emergence for weed control because several varieties were sensitive to Metribuzin. Plots were hilled. Colorado potato beetles were controlled as required, except for the Superior and NYL235-4 plots in the demonstration section. Irrigation was applied two to three times.

4. Harvest. Tops were pulled by hand, followed by digging with a one row digger and harvesting by hand. The green-sprouted section was harvested July 16th, 79 days from planting. The cut section was harvested August 18th, 98 days from planting. The demonstration section was harvested when tubers were need for the Open House and other displays.

5. Data collection. Tubers from the inside two rows/plot of the greensprouted and cut seed replicates were sized as follows : 3/4 - 1 5/8"; 1 5/8 - 1 7/8"; 1 7/8 - 2"; 2 - 2 1/4"; 2 1/4 - 2 3/4"; 2 3/4 - 3"; 3 - 3 1/2" and > 3 1/2". Tuber number and weight per size category were recorded. Notes were taken regarding bruising, knobs, roughs, growth cracks, scab, rhizoctonia, wireworm damage and sunburn.

When calculating "marketable yield", Canada No. 1 standards prior to September 15 were applied for round types, ie. 1 7/8 - 3 ½ ". For the long types, which included Coastal Russet, Goldrush, Miriam and Norgold Russet, Canada No. 1 after July 1st applied, ie. 2 - 3 ½ ". All knobby, rough or tubers with growth cracks, regardless of size, were considered culls and were only included in TOTAL weight and TOTAL tuber number. Yield was not measured from the demonstration section.

Ten pound samples from the greensprouted and cut seed sections were put through a wash line and ranked for skinning using the following numeric scale : 1 – none; 3 – mild; 5 – moderate; 7 – much; and 9 – severe.

Total glycoalkyloids were measured for ND3574-5R, All Blue, All Red and check variety Superior by Dr. Russ King, AAFC, Fredericton.

Seed Production for 1999 Trial. Seed plots of sixteen varieties were planted at the New Brunswick Horticulture Centre, Hoyt and entered for certification. Seven main varieties were planted May 14th, using seed produced at the NBHC by the project in 1999: AC Ptarmigan, ND3574-5R, NorDonna, Norgold Russet, OAC Ruby Gold, OAC Temagami, and Quaggy Joe. These were warmed and held under plastic in the grading area of the NBHC for 10 days prior to planting. At planting, only Norgold Russet was well sprouted and OAC Temagami and OAC Ruby Gold were pipping. Plots were 4 rows wide and varied in length from 45 to 85 feet depending on seed availability. In-row spacing varied from 9 – 12 inches and tuber uniting was applied. These plots were hilled June 16th. Another nine plots were planted June 14th from transplants (Plant Propagation Centre/hardened off at Bon Accord) : Carola, Longlac, McIntosh Black, McIntyre, Mouraska, Purple Viking, Rhine Red, River John Blue and Russian Blue. Transplants were planted approximately 6" apart, with 21 to 30 TP's per plot. An average of 100 lbs N/acre was applied as 15-15-15 fertilizer. Trickle irrigation tape was installed soon after planting. The irrigation system was used as required (water only) from June through August during this the hottest, driest summer on record. It was shut off for the main plots following topkill, but continued on the transplants until August 24th. Plots were hand-weeded. They were sprayed with Thiodan (June 10) and Admire (June 17) against Colorado potato beetles. Isolated infestations of dark blister beetles (the "old fashioned" potato bug) were spot sprayed with Thiodan June 14th. Bravo was used for late blight prevention July 22, August 3, 13 and 23. From late June through late August, a yellow pan trap was emptied biweekly to monitor winged aphid populations in the field. The final certification inspection was August 6th. Topkill of the main plots was Reglone applied August 9th followed by a spot application August 24th. Transplants were topkilled with Reglone August 27th. The main plots were harvested September 15th and the TP's October 4th. During harvest, samples were taken from all plots for bacterial ring rot testing.

Results

Greensprouted. Seedling F80054 (a yellow fleshed selection from the AAFC program in Fredericton) along with Adora (a pale yellow Hettema variety) started to greensprout the fastest, followed closely by Dark Red Norland, Eramosa, Norgold Russet and the ND 3574-5R (an early red skinned selection from North Dakota).

Once planted, Yukon Gold lagged behind the others in emergence and never caught up. CalWhite and F80054 got off to the fastest start growth wise, followed by ND 3574-5R, Nordonna and Envol. This early growth by NorDonna was not reflected later in yields however.

Yield and tuber data for the greensprouted section is given in Tables 1 and 2. There were few significant differences in total yield and Canada No. 1, although most varieties yielded well. Of the round whites, AC Ptarmigan, CalWhite and Quaggy Joe were similar to the check Eramosa (208 cwt/acre) at this 79 day harvest. CalWhite had produced a greater total yield but similar Canada No. 1 yields to Eramosa in the 1998 greensprouted trial at both 70 and 84 days. AC Ptarmigan produced similarly to the cut seed check Superior in 1998 at both 83 and 99 days. The variety Envol, represented by La Patate Lac St-Jean, yielded even better and at 225 cwt/acre matched Jemseg, which yielded 227 cwt/acre.

Norgold Russet outyielded Goldrush, especially regarding Canada No. 1 and had the highest average Canada No. 1 tuber weight of all varieties, at 149 g/tuber. In 1998, Norgold Russet (cut seed) had produced a higher total yield than Goldrush.

It was hard to rate the yellow flesh varieties due to the poor yield of the check Yukon Gold at only 110 cwt/acre. Adora and F80054 produced almost twice as much at 201 cwt/acre and 217 cwt/acre respectively. In 1998 when both were planted as cut seed, F80054 produced similarly to Yukon Gold at 99 days but with a higher percentage Canada No. 1, 83% versus 75%.

With the reds, NorDonna yielded only one-third the check DR Norland and was the lowest in this section despite its early growth. At 230 cwt/acre, ND3574-5R matched Dark Red Norland (226 cwt/acre) in total yield and yielded a somewhat higher percentage of Canada No. 1 (93 vs 88%). It also had slightly heavier tubers on average. One of the other advantages of this ND seedling is how well it keeps its red skin colour in storage. It is being grown by Spudtech and the NBDARD under an agreement with the University of North Dakota and is one to watch in the future. OAC Temagami (a red skinned, white flesh variety represented by the Ontario Seed Potato Growers Association) at 103 cwt/acre produced less than half the check Dark Red Norland.

M121

IMPORTANT NOTE CONCERNING THE FOLLOWING PAGES

THE PAGES WHICH FOLLOW HAVE BEEN FILMED TWICE IN ORDER TO OBTAIN THE BEST REPRODUCTIVE QUALITY

USERS SHOULD CONSULT ALL THE PAGES REPRODUCED ON THE FICHE IN ORDER TO OBTAIN A COMPLETE READING OF THE TEXT.

REMARQUE IMPORTANTE CONCERNANT LES PAGES QUI SUIVENT

LES PAGES SUIVANTES ONT ÉTÉ REPRODUITES EN DOUBLE AFIN D'AMÉLIORER LA QUALITÉ DE REPRODUCTION

LES UTILISATEURS DOIVENT CONSULTER TOUTES LES PAGES REPRODUITES SUR LA FICHE AFIN D'OBTENIR LA LECTURE DU TEXTE INTÉGRAL

micromedia
a division of IHS Canada

20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca

Table 1. Yield, tuber number and tuber weight for greensprouted potato varieties harvested July 16, 1999, 79 days after planting

Variety	*Total*		*Canada No. 1*			
	Yield (cwt/Ac)	# tubers /plot	Yield (cwt/Ac)	# tubers /plot	g per tuber	% Yd of total
AC Ptarmigan	206 a	101 ab	179 a	74 ab	114	87
Adora	201 a	103 ab	177 a	76 ab	109	88
CalWhite	205 a	90 bc	190 a	77 ab	116	93
Dark Red Norland	226 a	117 a	198 a	88 a	106	88
F80054	217 a	104 ab	194 a	80 a	114	89
Envol	225 a	104 ab	209 a	88 a	112	93
Eramosa	208 a	88 bc	200 a	80 a	117	96
Goldrush	169 a	103 ab	103 bc	45 cd	108	61
Jemseg	227 a	92 bc	216 a	80 a	127	95
ND 3574-5R	230 a	101 ab	213 a	82 a	122	93
NorDonna	77 b	81 cd	29 d	18 e	77	38
Norgold Russet	198 a	78 cd	170 a	54 cd	149	86
Quaggy Joe	199 a	107 ab	171 a	78 a	102	86
OAC Ruby Gold	170 a	77 cd	153 ab	60 bc	120	90
OAC Temagami	103 b	75 cd	74 cd	40 d	86	72
Yukon Gold	110 b	64 d	88 cd	41 d	101	81

Letters indicate a statistical difference using Duncan's Multiple Range test, $p = 0.05$. Analysis not carried out for g/tuber and % of Total yield. Canada No. 1 for long types 2 - 3 ½ " (Goldrush, Norgold Russet); for rounds (the rest) 1 7/8 - 3 ½ ". Total Yd : includes < 1 7/8" or < 2" and "culls" (roughs, growth cracks, knobs) together with Canada No. 1

Table 2. Yield in cwt/acre for greensprouted trial, harvested July 16, 1999, 79 days after planting

Variety	*Size Category*						
	3/4 - 1 5/8"	1 5/8- 1 7/8"	1 7/8 - 2"	2 - 2 1/4"	2 1/4- 2 3/4"	2 3/4 - 3"	3 - 3 1/2"
AC Ptarmigan	5.5	21.4	21.4	47.9 abc	88.2 abc	13.1	8.4 ab
Adora	4.6	18.9	20.9	55.3 a	74.6 abc	21.8	4.4 ab
CalWhite	2.6	11.0	18.6	55.2 a	96.4 abc	17.8	2.3 ab
Dark Red Norland	5.5	20.5	18.1	57.0 a	92.9 abc	15.9	14.5 ab
F80054	5.3	18.0	14.2	50.7 ab	105.6 ab	11.9	11.3 ab
Envol	2.2	13.0	16.1	44.3 a-d	104.6 ab	29.1	15.2 ab
Eramosa	0.7	7.1	9.4	35.3 bcd	107.9 ab	30.7	16.6 ab
Goldrush	7.6	28.3	29.5	49.5 ab	52.4 cd	1.6	0 b
Jemseg	2.6	8.1	6.4	34.3 bcd	107.4 ab	45.4	22.2 a
ND 3574-5R	4.4	11.6	9.6	50.0 ab	114.4 a	31.3	7.8 ab
NorDonna	20.7	26.3	14.4	5.5 e	8.3 e	0.9	0 b
Norgold Russet	5.3	10.3	11.4	34.5 bcd	82.9 abc	37.1	15.3 ab
Quaggy Joe	5.3	21.1	24.3	50.2 ab	75.3 abc	13.0	8.2 ab
OAC Ruby Gold	2.0	15.1	12.4	32.0 cd	64.6 bcd	23.5	20. 4 ab
OAC Temagami	7.6	20.4	15.5	28.4 d	27.8 de	2.1	0 b
Yukon Gold	4.9	15.9	16.8	31.1 d	29.5 de	8.3	2.7 ab

Letters indicate a statistical difference using Duncan's Multiple Range test, $p = 0.05$.

Table 1. Yield, tuber number and tuber weight for greensprouted potato varieties harvested July 16, 1999, 79 days after planting

Variety	*Total*		*Canada No. 1*			
	Yield (cwt/Ac)	# tubers /plot	Yield (cwt/Ac)	# tubers /plot	g per tuber	% Yd of total
AC Ptarmigan	206 a	101 ab	179 a	74 ab	114	87
Adora	201 a	103 ab	177 a	76 ab	109	88
CalWhite	205 a	90 bc	190 a	77 ab	116	93
Dark Red Norland	226 a	117 a	198 a	88 a	106	88
F80054	217 a	104 ab	194 a	80 a	114	89
Envol	225 a	104 ab	209 a	88 a	112	93
Eramosa	208 a	88 bc	200 a	80 a	117	96
Goldrush	169 a	103 ab	103 bc	45 cd	108	61
Jemseg	227 a	92 bc	216 a	80 a	127	95
ND 3574-5R	230 a	101 ab	213 a	82 a	122	93
NorDonna	77 b	81 cd	29 d	18 e	77	38
Norgold Russet	198 a	78 cd	170 a	54 cd	149	86
Quaggy Joe	199 a	107 ab	171 a	78 a	102	86
OAC Ruby Gold	170 a	77 cd	153 ab	60 bc	120	90
OAC Temagami	103 b	75 cd	74 cd	40 d	86	72
Yukon Gold	110 b	64 d	88 cd	41 d	101	81

Letters indicate a statistical difference using Duncan's Multiple Range test, $p = 0.05$. Analysis not carried out for g/tuber and % of Total yield. Canada No. 1 for long types 2 - 3 ½ " (Goldrush, Norgold Russet); for rounds (the rest) 1 7/8 - 3 ½ ". Total Yd : includes < 1 7/8" or < 2" and "culls" (roughs, growth cracks, knobs) together with Canada No. 1

Table 2. Yield in cwt/acre for greensprouted trial, harvested July 16, 1999, 79 days after planting

Variety	***Size Category***						
	3/4 - 1 5/8"	1 5/8- 1 7/8"	1 7/8 - 2"	2 - 2 1/4"	2 1/4- 2 3/4"	2 3/4 - 3"	3 - 3 1/2"
AC Ptarmigan	5.5	21.4	21.4	47.9 abc	88.2 abc	13.1	8.4 ab
Adora	4.6	18.9	20.9	55.3 a	74.6 abc	21.8	4.4 ab
CalWhite	2.6	11.0	18.6	55.2 a	96.4 abc	17.8	2.3 ab
Dark Red Norland	5.5	20.5	18.1	57.0 a	92.9 abc	15.9	14.5 ab
F80054	5.3	18.0	14.2	50.7 ab	105.6 ab	11.9	11.3 ab
Envol	2.2	13.0	16.1	44.3 a-d	104.6 ab	29.1	15.2 ab
Eramosa	0.7	7.1	9.4	35.3 bcd	107.9 ab	30.7	16.6 ab
Goldrush	7.6	28.3	29.5	49.5 ab	52.4 cd	1.6	0 b
Jemseg	2.6	8.1	6.4	34.3 bcd	107.4 ab	45.4	22.2 a
ND 3574-5R	4.4	11.6	9.6	50.0 ab	114.4 a	31.3	7.8 ab
NorDonna	20.7	26.3	14.4	5.5 e	8.3 e	0.9	0 b
Norgold Russet	5.3	10.3	11.4	34.5 bcd	82.9 abc	37.1	15.3 ab
Quaggy Joe	5.3	21.1	24.3	50.2 ab	75.3 abc	13.0	8.2 ab
OAC Ruby Gold	2.0	15.1	12.4	32.0 cd	64.6 bcd	23.5	20. 4 ab
OAC Temagami	7.6	20.4	15.5	28.4 d	27.8 de	2.1	0 b
Yukon Gold	4.9	15.9	16.8	31.1 d	29.5 de	8.3	2.7 ab

Letters indicate a statistical difference using Duncan's Multiple Range test, $p = 0.05$.

Cut seed. This cut seed section included a large number of protected varieties. Seven are represented by CanAgrico Potato Corporation, one by ZPC and two by the Ontario Seed Potato Growers Association. Yield and tuber data are given in Tables 3 and 4. Of the yellow fleshed varieties only one, Columbo (231 cwt/acre), significantly outyielded the control Yukon Gold (147 cwt/acre). Columbo was the highest yielder in this section, even though its average Canada No. 1 tuber weight (113 g/tuber) was about 15% less than that of Yukon Gold. The varieties Eloge, Maranca and OAC Ruby Gold (red-skinned however) also out-yielded Yukon Gold though the differences were not significant. Their individual tubers were also lighter than the control's. Morning Gold, generally thought to tolerate drought well, did poorly this year with 106 cwt/acre, yielding less but not significantly so, than the control Yukon Gold. Penta, with pink eyes similar to Yukon Gold, also did not yield significantly less total yield with 120 cwt/acre. In 1998, Morning Gold and Penta total and Canada No. 1 yields had not differed significantly from the check Yukon Gold at both 83 and 99 days.

Quaggy Joe, with its bright white skin and pink eyes, produced somewhat less than the round white check Superior. It produced more tubers per hill, resulting in generally smaller tubers, although the average tuber weight was not that much less than it had produced in the greensprouted section. In 1998 it had been planted late.

Of the red varieties, NorDonna produced almost as poorly as it had in the greensprouted section. Although a larger percentage of tubers reached Canada No. 1 size, its total yield was still less than 80 cwt/acre. . In 1998, NorDonna had produced half the Dark Red Norland total yield at 70 days and had still not reached its yield at 99 days. ND 3574-5R (174 cwt/acre) produced similarly to Dark Red Norland (187 cwt/acre) as did OAC Temagami (190 cwt/acre). In 1998, OAC Temagami only yielded 2/3 of the check.

Coastal Russet and Norgold Russet produced similar yields, but these were not significantly better than the check Goldrush. In 1998, although the situation was similar at 70 days, by 99 days Norgold Russet was yielding higher than Goldrush and Coastal Russet less.

Demonstration. Most of the niche varieties in the demonstration section were purple or blue skinned, with white, yellow or blue flesh. This allowed growers the chance to compare some heritage varieties, such as Russian Blue with the more standard blue skin/blue flesh variety All Blue. The novelty variety All Red, also called Cranberry Red, with its red skin and pink flesh, was also on display. Its pink flesh was not found to be very appealing and you'd need to like a wet potato to enjoy it.

Table 3. Yield, tuber number and tuber weight for potato varieties harvested August 18, 1999, 98 days after planting

Variety	*Total*		*Canada No. 1*			
	Yield (cwt/Ac)	# tubers /plot	Yield (cwt/Ac)	# tubers /plot	g per tuber	% Yd of total
Appell	122 c-f	106	72	45 cde	75	59
Coastal Russet	167 a-e	81	95	33 ef	137	57
Columbo	231 a	122	194	81 a	113	84
Dark Red Norland	187 abc	101	165	79 a	97	88
Eloge	197 abc	127	160	82 a	91	82
Goldrush	144 b-f	85	95	41 def	109	66
Maranca	210 ab	106	175	74 ab	111	83
Matilda	157 a-e	126	89	51 b-e	82	57
Miriam	90 ef	72	28	15 f	89	31
Morning Gold	106 def	68	79	41 def	90	74
ND 3574-5R	174 a-d	93	152	66 a-d	107	87
NorDonna	75 f	57	55	31 ef	82	73
Norgold Russet	171 a-d	98	112	47 b-e	112	65
OAC Ruby Gold	222 ab	105	197	82 a	113	89
OAC Temagami	190 abc	115	152	72 abc	99	80
Penta	120 c-f	89	84	46 b-e	86	71
Quaggy Joe	167 a-e	103	133	66 a-d	95	80
Superior	208 ab	74	189	61 a-d	145	91
Yukon Gold	147 b-f	57	139	49 b-e	132	94

Letters indicate a statistical difference using Duncan's Multiple Range test, p = 0.05. Analysis not carried out for g/tuber and % of Total yield. Canada No. 1 for long types 2 - 3 ½ " (Coastal Russet, Goldrush, Miriam, Norgold Russet); for rounds (the rest) 1 7/8 - 3 ½ ". Total Yd : includes < 1 7/8" or < 2" and "culls" (roughs, growth cracks, knobs) together with Canada No. 1

Table 3. Yield, tuber number and tuber weight for potato varieties harvested August 18, 1999, 98 days after planting

Variety	*Total*		*Canada No. 1*			
	Yield (cwt/Ac)	# tubers /plot	Yield (cwt/Ac)	# tubers /plot	g per tuber	% Yd of total
Appell	122 c-f	106	72	45 cde	75	59
Coastal Russet	167 a-e	81	95	33 ef	137	57
Columbo	231 a	122	194	81 a	113	84
Dark Red Norland	187 abc	101	165	79 a	97	88
Eloge	197 abc	127	160	82 a	91	82
Goldrush	144 b-f	85	95	41 def	109	66
Maranca	210 ab	106	175	74 ab	111	83
Matilda	157 a-e	126	89	51 b-e	82	57
Miriam	90 ef	72	28	15 f	89	31
Morning Gold	106 def	68	79	41 def	90	74
ND 3574-5R	174 a-d	93	152	66 a-d	107	87
NorDonna	75 f	57	55	31 ef	82	73
Norgold Russet	171 a-d	98	112	47 b-e	112	65
OAC Ruby Gold	222 ab	105	197	82 a	113	89
OAC Temagami	190 abc	115	152	72 abc	99	80
Penta	120 c-f	89	84	46 b-e	86	71
Quaggy Joe	167 a-e	103	133	66 a-d	95	80
Superior	208 ab	74	189	61 a-d	145	91
Yukon Gold	147 b-f	57	139	49 b-e	132	94

Letters indicate a statistical difference using Duncan's Multiple Range test, $p = 0.05$. Analysis not carried out for g/tuber and % of Total yield. Canada No. 1 for long types 2 - 3 ½ " (Coastal Russet, Goldrush, Miriam, Norgold Russet); for rounds (the rest) 1 7/8 - 3 ½ ". Total Yd : includes < 1 7/8" or < 2" and "culls" (roughs, growth cracks, knobs) together with Canada No. 1

Table 4. Yield in cwt/acre for potato varieties harvested August 16, 1999, 98 days after planting

Variety	***Size category***						
	¾ - 1 5/8"	1 5/8 - ` 7/8"	1 7/8 – 2"	2 – 2 ¼ "	2 ¼ " –2 ¾ "	2 ¾ - 3"	3 –3 ½ "
Appell	13.1	34.3	28.6 a-d	33.7	9.6	0	0
Coastal Russet	9.4	28.8	33.7 a	66.8	27.9	0	0
Columbo	5.5	17.4	18.6 c-f	48.6	81.8	26.3	19.0
Dark Red Norland	5.6	9.4	17.1 d-g	53.6	79.2	10.9	3.8
Eloge	12.3	18.1	22.7 b-e	55.1	67.0	14.3	1.3
Goldrush	6.3	21.9	20.4 b-f	45.2	45.7	4.2	0
Maranca	6.8	15.7	21.9 b-e	49.9	83.4	17.9	2.5
Matilda	20.0	39.8	30.2 ab	41.4	17.7	0	0
Miriam	8.4	20.4	11.3 efg	19.1	9.0	0	0
Morning Gold	6.0	9.6	14.4 efg	24.2	35.5	4.8	0
ND 4574-5R	9.6	14.6	18.3 c-f	48.4	63.1	8.6	13.3
NorDonna	8.8	10.9	12.8 efg	22.8	19.2	0	0
Norgold Russet	7.8	20.9	29.3 abc	53.0	50.1	6.9	1.7
OAC Ruby Gold	4.3	10.9	18.3 c-f	42.4	100.5	32.3	3.8
OAC Temagami	7.2	25.1	25.9 a-d	45.8	58.2	12.3	10.2
Penta	10.1	23.9	20.7 b-f	24.4	35.1	1.7	2.3
Quaggy Joe	6.9	25.5	21.7 b-e	44.9	47.6	13.3	5.6
Superior	1.4	7.0	9.4 fg	20.9	70.7	51.0	37.2
Yukon Gold	1.1	5.1	6.3 g	17.8	61.6	19.0	33.8

Letters indicate a statistical difference using Duncan's Multiple Range test, p = 0.05

Table 4. Yield in cwt/acre for potato varieties harvested August 16, 1999, 98 days after planting

Variety	*Size category*						
	¾ - 1 5/8”	1 5/8 - ` 7/8”	1 7/8 – 2”	2 – 2 ¼ “	2 ¼ “ –2 ¾ “	2 ¾ - 3”	3 –3 ½ “
Appell	13.1	34.3	28.6 a-d	33.7	9.6	0	0
Coastal Russet	9.4	28.8	33.7 a	66.8	27.9	0	0
Columbo	5.5	17.4	18.6 c-f	48.6	81.8	26.3	19.0
Dark Red Norland	5.6	9.4	17.1 d-g	53.6	79.2	10.9	3.8
Eloge	12.3	18.1	22.7 b-e	55.1	67.0	14.3	1.3
Goldrush	6.3	21.9	20.4 b-f	45.2	45.7	4.2	0
Maranca	6.8	15.7	21.9 b-e	49.9	83.4	17.9	2.5
Matilda	20.0	39.8	30.2 ab	41.4	17.7	0	0
Miriam	8.4	20.4	11.3 efg	19.1	9.0	0	0
Morning Gold	6.0	9.6	14.4 efg	24.2	35.5	4.8	0
ND 4574-5R	9.6	14.6	18.3 c-f	48.4	63.1	8.6	13.3
NorDonna	8.8	10.9	12.8 efg	22.8	19.2	0	0
Norgold Russet	7.8	20.9	29.3 abc	53.0	50.1	6.9	1.7
OAC Ruby Gold	4.3	10.9	18.3 c-f	42.4	100.5	32.3	3.8
OAC Temagami	7.2	25.1	25.9 a-d	45.8	58.2	12.3	10.2
Penta	10.1	23.9	20.7 b-f	24.4	35.1	1.7	2.3
Quaggy Joe	6.9	25.5	21.7 b-e	44.9	47.6	13.3	5.6
Superior	1.4	7.0	9.4 fg	20.9	70.7	51.0	37.2
Yukon Gold	1.1	5.1	6.3 g	17.8	61.6	19.0	33.8

Letters indicate a statistical difference using Duncan’s Multiple Range test, p = 0.05

A New York selection, NYL235-4, was included due to its reported high degree of natural resistance to Colorado potato beetles, leafhoppers and flea beetles. It produced a tremendous set, 30 or so tubers per hill. But the CPB's were not hindered by its trichomes, source of its "reported" resistance, and they had a royal feast.

Of interest from this section was Longlac, a long white variety with bluish/purple skin. It's an early variety, 75 days, which produced an extremely uniform set of marketable tubers. Good as a baker and for french fries, seed was produced at Hoyt so as to be able to include it in a replicated yield trial in 2000.

Total glycoalkyloid levels. TGA levels were ND3574-5R = 5.58 mg/100g ; All Blue = 12.00 mg/100g ; All Red = 9.14 mg/100 mg and Superior = 3.97 mg/100g. These were all within the limit for TGA levels in potatoes used for human consumption of 20 mg TGA per 100 gram fresh weight of whole tuber.

Seed production. All varieties passed certification. Plots were rogued as required but only one questionable leafroll plant was found despite the presence of buckthorn aphids in the yellow pan trap during 1998 prior to roguing of both mosaic and leafroll. A total of 58 cwt of seed was produced. Yields from the main plots, when calculated on a cwt/acre basis, varied from 277 cwt/acre for NorDonna to 529 cwt/acre for Quaggy Joe. From planting to topkill for these main plots was only 87 days. Other plots yielded, on a cwt/acre basis: OAC Temagami (360); OAC Ruby Gold (380); Norgold Russet (368); ND3574-5R (470) and AC Ptarmigan (514). The transplants yielded 20 – 30 lbs/plot. All BRR test results were negative.

Yellow pan trap winged aphid catches are given in Table 5. Buckthorn aphids were found early, during mid to late June, but fortunately there were no visible sources of leafroll or mosaic to be spread. No green peach aphids were caught in 1999, whereas a cumulative catch of four had been reached in 1998. There were fewer "other" aphids in 1998, a cumulative catch of 49 versus 572 in 1998.

Seed from 1998 was used at the Grand Lake site plus in a trial in Bouctouche, some was included in demonstrations in Hartland and Grand Falls, and some was planted by three tablestock growers. Approximately 180 kg each of OAC Ruby Gold, OAC Temagami and NorDonna seed were sent to Cuba through NB AGRIEXPORT for variety trials in that important NB market.

Promotion. An important activity of this SPUDTECH project has become the promotion of new varieties to the public. Once again this year there was an Open House held at Windy Hill Farm in August. It was very well attended, not only by the growers of the Southeastern NB Horticulture Association, various provincial and federal staff and private variety representatives, but by young and old from the general public. More than 70 people came out to view the new potatoes and got to take home samples of some of the public varieties.

Table 5. Yellow pan trap catches of winged aphids, NB Horticulture Centre, Hoyt, 1999

Collection date	Green Peach	Common Potato	Buckthorn	Other
June 18	0	0	2	0
June 22	0	8	8	2
June 25	0	0	4	0
June 29	0	0	0	0
July 6	0	0	0	2
July 8	0	0	0	1
July 12	0	2	1	0
July 15	0	1	0	13
July 20	0	0	0	18
July 23	0	1	0	3
July 26	0	0	0	1
July 30	0	0	0	9
August 13	0	0	0	0
August 17	0	0	0	0
August 23	0	0	0	0
August 26	0	1	0	0
TOTAL	0	13	15	49

Potatoes from this trial were also used in displays at the NB Horticulture Centre at Hoyt, the Queen's County Fair and then at the Stanley Fair. The general public is still surprised to see potatoes in so many colours and shapes, and were very keen to collect recipe cards provided by the NB Potato Agency on new ways to "spiff up" their spuds.

Discussion

The 1999 growing season in New Brunswick was the hottest and driest on record. Although irrigated a couple of times, the dry conditions later in the summer clearly affected yields and the greensprouted plots benefited from their early start. Plots in the cut seed section were harvested 98 days after planting, and thus grew 20 days longer than the greensprouted plots. However, yields of several varieties which were planted in both sections were lower when planted later as cut seed. This was the case for Dark Red Norland, Goldrush, ND 3574-5R, Norgold Russet and Quaggy Joe. Only OAC Ruby Gold, OAC Temagami and Yukon Gold produced more in the cut seed plots than in the greensprouted section, where the latter two had produced very poorly.

In the greensprouted section, CalWhite, AC Ptarmigan, F80054 and Quaggy Joe continued to show promise for the early market. Adora (white to pale yellow flesh), Envol (round white) and ND3574-5R (red skin) also showed promise and should be watched. Planted as cut seed and with a slightly longer growing season, the yellow fleshed Columbo was the new variety of most interest, followed by Maranca, Eloge and ND3574-5R. OAC Ruby Gold produced well but requires a market for red skin, yellow flesh. NorDonna produced generally poor yields in 1999.

Trial details for 2000 will be decided upon in consultation with growers of the SE New Brunswick Horticulture Association.

Acknowledgements

The author wishes to thank the grower cooperator John Gunter of Windy Hill Farm, Whites Cove for his participation in this trial, maintenance of the plots and promotional activities, and to Andrew Currie (NBDARD) for his coordinating activities. Thanks also go to Charity Gunter, Sandy Perley (NBDARD), various summer students, employees of Windy Hill Farm and students of the Middle Level class of the Cambridge Narrows School for their assistance, also to the staff of the NBHC for the production of seed. Funding for this project was provided by the Strategic Partnership Development Fund (ARP98018-1) and the NB Potato Agency.

NATUREMARK™ KYLE EVALUATION
HARTLAND, NB - 1999

EVALUATION DE CLONES KYLE DE NATUREMARK^{MC}
HARTLAND (N.-B.) 1999

Peter K. Scott[1] and/et Janet McLaughlin[1]

Partner/Partenaire: New Brunswick Potato Agency (SPUDTECH)/Agence de la pomme de terre du Nouveau Brunswick(SPUDTECH)

Abstract: A total of three transgenic NatureMark™ clones (KYLE) were evaluated for agronomic performance at Hartland, NB in 1999. Three clones with genetic modification for CPB resistance, PVY and PLRV immunity were compared to the standard Russet Burbank. Clone KYLE 086 had reduced total yields but all were equal for marketable US#1 yields and specific gravity with few defects. Additional quality evaluations are being conducted during the 1999-2000 storage season.

Résumé: Un essai réalisé en 1999 à Hartland (N.-B.) a permis d'évaluer la performance agronomique de clones transgéniques (KYLE) de NatureMark^{MC}. Trois clones modifiés génétiquement pour leur conférer une résistance au doryphore de la pomme de terre et une immunité contre le virus Y et le virus de l'enroulement ont été comparés à la Russet Burbank standard. Le clone KYLE 086 a donné des rendements totaux réduits, mais tous les clones se comparaient en ce qui concerne les rendements commercialisables de classe US n° 1, la densité et le peu de défauts. Des évaluations additionnelles de la qualité seront effectuées durant la période d'entreposage de 1999-2000.

Introduction

The introduction of potato varieties with 'genetic modifications' started with the NewLeaf™ material by NatureMark Potatoes Inc., providing a few traditional varieties with resistance to Colorado Potato Beetle. This was the first wave of genetically modified material that could be seen as either cost reducing or even yield enhancing to the producer. This has been in material that would permit either reduced input by the producer due to a built in resistance to insects or disease or in a royalty payment for this technology.

This trial included a new round of material (nicknamed KYLE) that has resistance to Colorado Potato Beetle, Potato Virus Y and Potato Leaf Roll Virus. This material must be grown in a confined trial site, separated from other varieties and monitored for 2 years for volunteer growth. The production from this confined trial must also be disposed of in accordance with Canadian Food Inspection Agency specifications.

---

[1] Potato and Agricultural Resource Centre, NBDARD, 39 Barker Lane, Wicklow, NB E7L 3S4 / Centre des ressources de la pomme de terre, MAARNB, 39, allée Barker, Wicklow, NB E7L 3S4

Materials and Methods

This trial consisted of 25 ft-long triple row plots in a randomized complete block design with six replications. The center row of each replicate was used for grade and quality determination and the outer rows were placed into 15 tuber sample bags that were then put into storage at the Potato Storage Management Centre for future testing. Planting was conducted by hand into rows opened by the cooperating grower using a commercial 4-row planter. A 12-15-18 analysis fertilizer was banded at row opening at a rate of 1300 lbs/acre. A systemic insecticide (Imidacloprid) was also placed in-furrow at planting. Fresh-cut seed at a 2 ounce (58 g) average weight and treated with a fungicide dust an in-row spacing of 14 inches (35 cm).

All plots were dug with a single row plot harvester, placed into mesh bags, and then transported to the Potato Storage Management Centre for future grading. Each sample was hand graded into 5 size categories (1 = <4 oz.; 2 = 4 - 6 oz; 3 = 6 – 10 oz; 4 = 10 – 12 oz; 5 = > 12 oz, 6= > 10 oz) and then sorted for internal and external defects. Marketable yields are reported as total yield less external defects and < 4 oz size category. Stem counts were made soon after full emergence. Hollow heart and brown center determination were conducted on the two largest size categories in each sample. Specific gravity was determined using the weight-in-air/weight-in-water method using the four largest size categories.

Results and Discussion

Early season growing conditions were very dry with precipitation at 85% of normal persisting into late July. August received above average rainfall however, it all occurred in two rain events mid-month. There was some evidence of leaf mottling observed within the KYLE lines early in their growth but this was quickly surpassed. Although early season growth was reduced due to the dry conditions there was no problem with late blight during 1999. This site also had very good weed and insect control with only a minor attack from European Corn Borer.

Although clone KYLE 086 had a reduction in total yield there were no differences noted in the amount of US #1 yield (Table 1). KYLE 086 also had the least amount of US #2 tubers making it the clone with the best tuber type and having more blocky tubers.

The length of tubers was the greatest for KYLE 037 and KYLE 088 with KYLE 086 comparing to the control Russet Burbank. Specific gravity of these lines was in general low, ranging from 1.0676 to 1.0717 for the control. In general, the tubers were very rough with a lot of pointed, bottleneck and second growth due to the drought conditions experienced early in 1999. Very few internal defects were

Table 1. Total Yield, US #1 and US #2 Marketable Yields including percentage of total yields with length x width ratios and specific gravity for three multi-trait Russet Burbank clones (KYLE) grown at Hartland, NB – 1999.

	Total Yield Cwt/ac	**US #1**		**US # 2**		**L x W**	**Specific Gravity**
		Cwt/ac	**%**	**Cwt/ac**	**%**		
KYLE 037	364.12 a*	174.71 a	48	90.61 a	25	2.669 a	1.0689 bc
KYLE 086	279.70 b	173.44 a	62	44.79 b	16	2.278 b	1.0711 ab
KYLE 088	350.48 a	159.99 a	46	111.85 a	32	2.799 a	1.0676 bc
CONTROL	365.15 a	179.92 a	49	115.77 a	32	2.375 b	1.0717 a
LSD 0.05	28.02	52.2		34.02		0.186	0.00259
CV	6.70						0.1966

*Numbers followed by different letters within each column are significantly different at the 5% level by Duncan's multiple comparison test.

Table 2. Internal defects of hollow heart and brown center with stems per plant and tubers per plant for three multi-trait Russet Burbank clones (KYLE) grown at Hartland, NB – 1999.

	Hollow Heart	Brown Centre	Stems/Plant	Tubers/Plant
KYLE 037	0.0 b	0.0 a	4.21 a	12.29 a
KYLE 086	219.8 a	0.0 a	3.25 b	8.90 c
KYLE 088	0.0 b	84.7 a	3.05 b	11.09 ab
CONTROL	0.0 b	0.0 a	3.32 b	9.85 bc
LSD .0.05	111.9	127.6	0.399	1.56

*Numbers followed by different letters within each column are significantly different at the 5% level by Duncan's multiple comparison test.

observed, however KYLE 086 did have a higher amount of hollow heart (Table 2). KYLE 036 had higher stem numbers per plant and a higher number of tubers per plant at 12.29.

The tuber size distribution for this material provided for a reduction in the size profile for all the new lines when compared to the control Russet Burbank (Table 3). KYLE 086 resembled the control Russet Burbank while KYLE 037 and KYLE 088 produced smaller tuber sizes. The control Russet Burbank had the highest yield of over 10 ounce tubers with 57.1 cwt, followed by KYLE 086

Table 3. Tuber size distribution for three multi-trait Russet Burbank clones (KYLE) grown at Hartland, NB – 1999.

	Size Distribution[1] of US #1					
	1	2	3	4	5	6
	Cwt/acre					
KYLE 037	98.8	62.3	88.5	11.8	12.1	23.9
KYLE 086	61.5	53.3	73.5	24.8	21.9	46.7
KYLE 088	78.6	55.5	74.6	17.9	11.9	29.8
RUSSET BURBANK	69.5	41.6	81.1	21.9	35.2	57.1

[1] 1 = >4 oz.; 2 = 4 - 6 oz; 3 = 6 - 10 oz; 4 = 10 - 12 oz; 5 = > 12 oz, 6= > 10 oz.

having 46.7 cwt. The lowest 10 ounce was recorded by KYLE 037 which also had the highest yield of tubers under 4 ounces.

Conclusions

The data in this report is for one year and one location but demonstrates that there was little agronomic performance differences with this genetic material. Under the dry growing conditions there was a high amount of rough and knobby tubers but in general good yields were experienced with a slight reduction in specific gravity. Storage evaluations continue on this material to evaluate these lines for processing quality and storability.

Acknowledgements

The authors wish to thank Robert Seeley and staff for excellent management of this trial, SPUDTECH for their support and the Strategic Partnership Development Fund for funding, as well as the interest and support provided by NatureMark™ Potatoes.

PERFORMANCE EVALUATION OF POTATO CLONES AND VARIETIES IN THE NORTHEAST, NE-184, HARTLAND, NB - 1999

ÉVALUATION DE LA PERFORMANCE DE CLONES ET DE VARIÉTÉS DE POMMES DE TERRE DANS LE NORD-EST, NE-184 HARTLAND (N.-B.) 1999

P.K.Scott[1], H. DeJong[2], T.R. Tam[2], G.C.C. Tai[2], A.M. Murphy[2]
and/et C. Murray[2]

Abstract: An evaluation trial to evaluate the performance of twenty potato clones and varieties for field and culinary characteristics was conducted at Hartland, N.B. The twenty clones consisted of 10 non-russet and 10 russet entries. Total yields of all clones ranged between 201 cwt/ac for Russet Norkotah 3117 and 443 cwt/ac for NY101. Both Russet Norkotah 003 and Russet Norkotah 008 produced higher yields than the original clone 3117. The highest and lowest tuber appearance scores were obtained by NY 112 and Russet Burbank, respectively. The highest combined chip scores from all four temperature regimes was obtained by NY115.

Résumé : Un essai a été réalisé à Hartland (N.-B.) pour évaluer la performance au champ et les caractéristiques culinaires de vingt clones et variétés de pommes de terre. Les vingt clones provenaient de dix variétés de pomme de terre à peau rugueuse et de dix autres variétés. Les rendements totaux variaient de 201 quintaux l'acre (Russet Norkotah 3117) à 443 quintaux l'acre (NY101). Les clones Russet Norkotah 003 et Russet Norkotah 008 ont donné des rendements supérieurs au clone original 3117. La cote la plus élevée et la cote la plus basse relativement à l'aspect des tubercules ont été attribuées à NY112 et Russet Burbank respectivement. De toutes les variétés à croustilles, NY115 a obtenu les cotes combinées les plus élevées aux quatre régimes de température.

Introduction

A maincrop trial containing a total of 20 entries (10 non-russet and 10 russet) was conducted in New Brunswick as part of the 1999 NE-184 Regional Project. The NE-184 continues as a regional project including the Eastern United States and Eastern Canada. This multi-state and provincial trial network allows for the extensive evaluation of new potato clones over a wide range of climatic zones. This permits each of the submitting breeding programs to have advanced clones evaluated and rated across diverse conditions, and allows for collection of excellent performance data.

The trial was conducted in Hartland, NB. The plot area was rented and the crop and pest management practices, other than planting and harvesting, were done by the grower with commercial-scale equipment.

---

[1] Potato and Agricultural Resources Centre, NBDARD, 39 Barker Lane, Wicklow, NB E7L 3S4 / Centre des ressources de la pomme de terre, MAARNB, 39, allée Barker, Wicklow, NB E7L 3S4

[2] Agriculture & Agri-Food Canada, Potato Research Centre, Fredericton, NB E3B 4Z7 / Agriculture et Agroalimentaire Canada, Centre de recherches de la pomme de terre, Fredericton, NB E3B 4Z7

Materials and Methods

The trial consisted of 25-ft-long, single-row plots in a randomized complete block design with four replications. The seed was received pre-cut and in excellent condition; the trial was planted May 18 and 1300 lbs/ac of 12-15-18 fertilizer was banded at planting time with a commercial four-row planter. A systemic insecticide (Imidacloprid) was also applied at planting time. Depending upon the cultivar, three different within-row spacings were used: 10, 12 or 14 inches; this allowed for 30, 24 or 21 hills per plot respectively (Table 1). There was no irrigation at this site. The first topkill (Reglone) was applied on Sept. 15 (120 days). The plots were harvested Oct. 5. Samples for specific gravities, boiling, baking, chipping and french frying were set aside at harvest time for subsequent analysis. Specific gravities were determined using the weight-in-air/weight-in-water method. In the boil and bake tests the entries were evaluated for the following quality components: appearance, texture, off-flavor, sloughing (for boiled only), and discoloration.

Results and Discussion

The early part of the growing season was relatively dry. The total precipitation from May to July inclusive was 85% of normal. Although the precipitation in August was 120% of normal, most of this occurred on two days (Aug. 8 and 14) thus a considerable amount of that precipitation was lost due to run-off. Partly as result of the relatively dry weather late blight was not a major problem. Weeds and insects were also very well controlled. Some atypical symptoms of early blight may have confounded the maturity readings of Russet Norkotah 3117 and Superior. These two entries have often shown considerable susceptibility to early blight at this site. A84118-3 had, for the second consecutive year, a maturity which was later than that of Russet Burbank (Table 1).

The overall yields were moderate. Three entries, Katahdin, NY 101 and NY 112 produced a significantly higher marketable yield than Kennebec. Russet Burbank and Russet Norkotah 3117 produced a marketable yield which was significantly lower than Kennebec. In the case of Russet Burbank this was due to a large amount of culls, the result of very knobby tubers. Russet Norkotah 3117 had a relatively low vigor throughout the growing season and produced rather small tubers. The overall specific gavities were moderately good. The highest specific gravity was produced by Atlantic; A81386-1 and AF1437-1 had the lowest specific gravities. For AF1437-1 this was the second consecutive year this entry had the lowest specific gravity in this trial.

The overall tuber appearances were moderate (Table 2). The highest and lowest tuber appearance scores were obtained by NY 112 and Russet Burbank respectively. The modest appearance score of C0083008-1 was primarily the result of tapering. This was also observed with this entry in 1998. Katahdin

Table 1. Plant spacing, early vigor, midseason vigor, maturity, total yield, marketable yield, size distribution, and specific gravity for 10 non-russet and 10 russet maincrop varieties grown at Hartland, New Brunswick, Canada – 1999

Variety	Plant spacing (")	Early vigor	Mid-season vigor	Mat.	Total yield (cwt/A)	Mark. yield[1]		Size distribution by class[2] (%)					Size distribution (%)		Specific gravity
						cwt/A	% of std[3]	1	2	3	4	5	1-7/8" to 4"	2-1/2" to 4"	
A082611-7	14	5	8	7	371	323	121	5	25	56	6	0	87	62	1.086
A81386-1	14	3	5	7	306	272	102	5	41	43	5	1	89	48	1.069
A8495-1	14	1	4	6	282	256	95	4	31	49	10	0	90	59	1.080
A84118-3	14	1	4	9	373	332	124	2	15	59	16	2	90	75	1.080
A84180-8	14	2	4	6	275	225	84	7	51	28	3	0	82	31	1.073
AF1437-1	10	4	6	4	311	295	111	3	18	59	18	1	95	77	1.069
Atlantic	10	6	7	7	316	296	111	2	10	45	38	2	93	83	1.090
B0766-3	10	4	5	7	298	291	109	0	6	51	40	1	98	91	1.079
COO83008-1	14	4	7	7	225	216	81	1	9	54	33	1	96	87	1.081
Katahdin	10	3	6	8	383	342	128	1	10	45	34	6	89	79	1.072
Kennebec (std)	10	7	8	7	337	266	100	2	11	38	31	2	79	68	1.072
NY101	10	4	6	8	443	413	155	4	21	53	19	1	93	73	1.074
NY112	10	6	7	7	392	379	142	1	10	62	25	1	97	87	1.084
NY115	10	5	5	6	263	250	94	3	22	58	14	0	94	73	1.077
Russet Burbank	14	2	7	8	355	132	49	7	29	8	1	0	37	8	1.071
R Norkotah3117	12	2	3	2	201	187	70	3	41	51	2	0	93	52	1.070
R Norkotah 003	12	3	4	8	359	292	110	3	12	50	20	0	82	70	1.072
R Norkotah 008	12	3	5	6	304	276	103	3	32	53	6	0	91	59	1.073
Superior	10	8	8	2	233	216	81	2	13	62	18	1	93	79	1.074
Yukon Gold	10	4	7	4	321	308	115	2	10	59	27	1	96	86	1.087
Waller Duncan (k = 100)					71	68	26								

[1] Marketable yield: 1-7/8" to 4"

[2] Size classes: 1 = 1-1/2" to 1-7/8"; 2 = 1-7/8" to 2-1/2"; 3 = 2-1/2" to 3-1/4"; 4 = 3-1/4" to 4"; 5 = over 4"

[3] Std. = Kennebec

Table 2. Tuber data, overall rating, and quality scores for 12 non-russet and 10 russet varieties grown at Hartland, New Brunswick, Canada-1999.

	Tuber Data								Chipping[3]				FF[5]	
Variety	Color	Texture	Shape	Eye Depth	Appear.	Overall rating	Boil score[1]	Bake score[2]	55°F Dec.	44°F Dec.	55°F Feb.	44°F Rec[4]	55°F Dec	44°F Dec
A082611-7	6	5	7	4	6	6	76	72	55	30	55	45	61	64
A81386-1	6	5	7	5	5	4	59	60	65	15	55	60	53	44
A8495-1	6	5	6	5	5	5	73	84	70	25	60	30	77	73
A84118-3	6	6	7	5	6	5	74	72	65	15	60	35	65	59
A84180-8	5	4	8	5	5	5	68	64	45	10	45	35	71	40
AF1437-1	7	8	2	4	4	4	73	67	65	10	55	35	–	–
Atlantic	6	7	2	3	6	6	78	84	60	40	55	55	–	–
B0766-3	7	8	2	5	4	5	71	69	65	40	60	55	–	–
COO83008-1	6	6	5	5	4	4	81	76	70	25	60	40	65	62
Katahdin	2	8	3	4	4	5	74	67	50	10	45	35	–	–
Kennebec	7	8	3	4	5	5	74	66	55	10	45	45	–	–
NY101	7	8	1	5	6	6	63	60	60	15	55	48	–	–
NY112	5	6	2	5	7	7	69	66	55	25	55	65	–	–
NY115	7	8	1	5	4	5	83	76	70	45	60	65	–	–
Russet Burbank	6	4	8	5	2	3	75	65	52	10	43	30	50	51
R Norkotah 3117	5	3	7	5	4	4	72	54	40	10	40	30	51	35
R Norkotah 003	5	3	8	4	6	6	69	50	45	10	45	40	47	40
R Norkotah 008	5	3	8	5	4	5	69	52	55	5	40	35	52	35
Superior	7	8	2	3	4	5	68	69	52	10	55	50	–	–
Yukon Gold	7	8	2	5	6	6	79	86	55	35	45	35	–	–

[1] Boil Score: <50 = unacceptable; 50-60 = fair; 60-70 = good, relatively moist texture; >70 = good, relatively dry texture.

[2] Bake Score: <55 = unacceptable; 55-65 = fair; 65-75 = good, relatively moist texture; >75 = good, relatively dry texture. (Score combines appearance, texture, off-flavor, discoloration and, for boil scores, sloughing).

[3] Based on a color card scale of 10-100; <50 = poor; 50 to 70 = moderate; 70 to 80 = good; >80 = excellent.

[4] After 4 weeks of reconditioning at 70°F.

[5] FF Score: <55 = poor; 55-65 = moderate; >65 = good.

received a modest appearance score because the tubers were of variable types and sizes as well as a bit flat. The appearance of NY 115 suffered as a result of the tubers being rather flat. The highest combined boil and bake score was obtained by Yukon Gold. This was closely followed by Atlantic, NY 115, A8495-1 and C0083008-1. The lowest combined boil and bake scores were obtained by A81386-1, Russet Norkotah 003, Russet Norkotah 008, NY101 and Russet Norkotah 3117. In the case of A81386-1 and NY101 the relatively low boil scores were the result of a wet texture; their low bake scores were due to both a poor appearance and a wet texture of the baked sample. The lowest bake scores in this trial were produced by the three Russet Norkotah clones and were considered unacceptable. For each of these three entries this was the result of a combination of a poor appearance as well as a wet texture of the baked samples. The best table entries, considering marketable yield, specific gravity, tuber appearance and boil and bake scores were Atlantic and Yukon Gold.

The highest combined chip scores from all four temperature regimes was obtained by NY115. This was closely followed by B0766-3, Atlantic and NY112. NY101 produced good chip color from 55°F in December but its mediocre chip scores from both the 44°F in December and after reconditioning, along with its relatively low specific gravity raises concerns about its potential as a chipping variety. The relatively low specific gravity and the moderate tuber appearance of NY115 are of some concern for this selection. B0766-3 also had a moderate tuber appearance score. This was primarily due to rough and knobby tubers. This was the third year that this selection was evaluated at this site. In previous years it produced a good tuber appearance score and has consistently produced good chip scores. NY112 produced an excellent yield and also obtained the highest tuber appearance score in this trial. Considering marketable yield, specific gravity, tuber shape, tuber appearance and chip scores, the best chipping entry was NY112. B0766-3 and NY115 are also potential candidates as new chipping varieties.

The best french fry scores were obtained by A8495-1. A082611-7, A84118-3, A84180-8 and C0083008-1 also produced acceptable french fry scores. The relatively short tubers of A8495-1 may require particular attention in the crop management for this entry to be a successful french fry variety. The consistent late maturity of A84118-3 may limit the adaptation of this entry to New Brunswick growing conditions. The combination of a modest yield, a high proportion of small tubers and a relatively low specific gravity of A84180-8 is of considerable concern for its french fry potential. The moderate yield and marginal tuber shape of C0083008-1 (oblong and tapering) detracts from its suitability as a french fry variety. If the relatively moderate french fry score (which is primarily due to the external appearance of the french fry slices) of A082611-7 can somehow be improved then this entry has good potential for the french fry industry.

Conclusions

Participation in the NE-184 potato development and evaluation project permits early access to potato cultivars under development by potato breeding programs in the Eastern United States. Agriculture and Agri-Food Canada and the New Brunswick Department of Agriculture and Rural Development have cooperated in the conduct of this trial on behalf of the New Brunswick potato industry for several years. This trial network allows New Brunswick potato growers access to potential future varieties through trial data and observations at open houses and field tours during the growing season. Participation in this trial should continue into the future to permit a hands-on look at new potato clones and cultivars.

Acknowledgements

The authors wish to thank Robert Seeley and staff for providing land and assistance, as well as the excellent management of this trial. Funding for this New Brunswick trial location was provided by the Potato Research Centre, Agriculture and Agr-Food Canada and the New Brunswick Department of Agriculture and Rural Development.

EFFECT OF MUSTER HERBICIDE CARRYOVER ON VARIOUS POTATO VARIETIES

ARRIÈRE-EFFET DE L'HERBICIDE MUSTER SUR DIVERSES VARIÉTÉS DE POMMES DE TERRE

Kevin V. McCully[1], Peter Scott,[2] Jacques Lavoie[3] and/et Gilles Godbout[4]

Abstract : Small plot research trials and a field scale trial were established to evaluate the effect of planting potatoes into soils which were treated with Muster 75 DF herbicide the previous year. The objectives were to determine if crop injury, quality, and yields would be negatively impacted across varieties. In the small plot research trials Muster + Agral 90 was applied at 20 g/ha + 0.2% v/v (1X), and 40 g/ha + 0.2% v/v (2X) rates the previous fall. In the field scale trial Muster + Agral 90 was applied at 15 g/ha + 0.2% v/v the previous spring. Crop injury visual ratings were collected in the small plot research trials, and potato yields were collected and graded in both the small plot and field scale trials. Results from the small plot research trials indicated that final crop injury ratings, total yields, and marketable yields from the four potato varieties evaluated (Superior, Atlantic, Shepody, and Russet Burbank) were not significantly different from the untreated control. These four varieties were therefore safe to replant into soil previously treated with Muster + Agral 90 at 20 g/ha + 0.2% v/v (1X). Overall potatoes were more sensitive to the (2X) 40 g/ha Muster rate. Crop injury ratings were higher, and total yields and marketable yields were lower than the untreated control. Although crop injury was higher and total and marketable yields lower on Atlantic and Russet Burbank varieties, they were not significantly different from the untreated control. Shepody marketable yields were also not significantly different from the untreated control. Superiors were the most sensitive variety and may be at risk for yield reductions if 2x Muster rates result from over application. Results from the large field scale trial also confirmed potatoes tolerance to Muster herbicide carryover when applied at 15 g/ha rates the year previous to planting potatoes. Shepody, Russet Burbank, and Gold rush varieties all were considered very tolerant. Total and marketable yield differences between the untreated and the treated fields was considered minor. Russet Norkotah yields were much lower than the untreated control but were the result of competition from volunteer Canola and not Muster carryover.

Résumé : Des essais sur petites parcelles et un essai en plein champ ont permis d'évaluer le comportement de pommes de terre plantées dans des sols traités avec l'herbicide Muster 75 DF l'année précédente. On cherchait à déterminer si la culture subirait plus de dommage et une baisse de qualité et de rendement d'une variété à l'autre. Dans les petites parcelles, on a appliqué l'automne précédent du Muster + Agral 90 à raison de 20 g/ha + 0,2 % v/v (1X) et de 40 g/ha + 0,2 % v/v (2X). Dans l'essai en plein champ, on a appliqué du Muster + Agral 90 à raison de 15 g/ha + 0,2 % v/v le printemps précédent. On a fait des évaluations visuelles et déterminé le rendement des pommes de terre des petites parcelles, qui ont été classées dans diverses catégories. Les résultats des essais dans les petites parcelles indiquent que l'endommagement final, le rendement total et le rendement commercialisable pour les quatre variétés de pommes de terre (Superior, Atlantic, Shepody et Russet Burbank) n'étaient pas beaucoup différents de ceux de la parcelle témoin non traitée. On peut donc planter ces quatre variétés sans risque dans les parcelles traitées précédemment avec le Muster + Agral 90 appliqué à raison de 20 g/ha + 0,2 % v/v (1X). Dans l'ensemble, les pommes de terre ont réagi davantage à la dose de Muster (2X) 40 g/ha. L'endommagement était plus considérable, et les rendements total et commercialisable étaient inférieurs à ceux de la parcelle témoin. L'endommagement était

---

[1] NB Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

[2] Wicklow Regional Office , NBDARD, Wicklow, NB E7L 3S4 / Bureau Regional de Wicklow, MAARNB, Wicklow, NB E7L 3S4

[3] Grand Falls Regional Office, NBDARD, Grand Falls, NB E3Z 1G1 / Bureau régional de Grand-Sault, MAARNB, Grand-Sault, NB E3Z 1G1

[4] Eagle Farm Ltd, Grand Falls, NB E3C 1E7 / Eagle Farms Ltd, Grand-Sault, NB E3C 1E7

plus considérable et les rendements total et commercialisable étaient inférieurs pour les variétés Atlantic et Russet Burbank, mais ils n'étaient pas beaucoup différents de ceux de la parcelle témoin. Le rendement commercialisable de la Shepody ne différait pas beaucoup non plus de celui de la parcelle témoin. La variété Superior était la plus sensible, et elle pourrait risquer de subir une baisse de rendement à la suite d'une application du double de la dose de Muster. Les essais en plein champ ont aussi confirmé que les pommes de terre toléraient l'arrière-effet de l'herbicide Muster appliqué à raison de 15 g/ha durant l'année qui précède la plantation des pommes de terre. Les variétés Shepody, Russet Burbank et Gold Rush sont toutes considérées comme tolérantes. On a qualifié de mineurs les écarts dans le rendement total et le rendement commercialisable entre les parcelles non traitées et les parcelles traitées. Le rendement de la Russet Norkotah était beaucoup plus bas que celui des parcelles non traitées, mais ce résultat était attribuable à la concurrence d'une repousse de canola, et non à l'arrière-effet du Muster.

Introduction

Hybrid seed canola production has been identified as a potential developmental and growth opportunity for New Brunswick farmers. In order for this industry to develop and become successful, high levels of weed control must be attained. For this reason data was generated to support the registration of Muster (ethametsulfuron methyl) herbicide through the Minor Use program (URMULE) for use in New Brunswick and the Maritimes.

Muster is a post emergent broadleaf herbicide that is applied in the spring to Canola between the 2 leaf and bolting stage of development. It is registered for use in the Maritimes at 15 g/ha with a non-ionic surfactant. One of the limitations with the use of this product however, is the potential for soil residue carryover which could injure crops replanted the following year. The current label permits only wheat, barley, oats, and winter wheat to be replanted. A number of Canola growers also grow potatoes within their rotation, so questions as to whether or not potatoes could be grown safely the year following Muster application needed addressed.

As a result, both small plot research trials and a large field scale trial were established to determine the effect of planting potatoes into soils which Muster had been applied to the previous year.

Materials and Methods

For the small plot research trials, Muster 75DF + Agral 90 was applied the fall before planting potatoes (November 23, 1998), at two different rates: 20 g/ha + 0.2 % v/v (1X) and 40g/ha + 0.2% v/v (2X). Treatments were applied with a hand held CO_2 sprayer.

Four potato varieties (Shepody, Superior, Atlantic and Russet Burbank) were planted the following spring on May 28, 1999 in Hartland N.B.. Atlantic, Superior and Shepody varieties were hand planted 20 cm apart within the row, and Russet Burbank's were planted 35 cm apart within the row. Distance between rows was 90 cm. For grass and broadleaf weed control within the potato plots, Fusilade II and Lexone 75 DF were applied on June 4th 1999, at a rate of 2L/ha and 0.56 kg/ha respectively. The soil type was a loam with a sand/silt/clay ratio of 32/45/23. The organic matter content was 2.7 % and the pH was 5.7.

The trial design was a randomized complete block with 3 replicates. The plots were 2*4 meters and included two rows per plot. The previous crop was barley.

Visual ratings on crop injury were collected June 24, July 15, July 22 and August 31 for each variety. Crop injury ratings were on a scale of 0-100, where 0 represented no injury and 100 represented a complete kill. Reglone was applied as a top killer to all varieties on September 21. Potatoes were harvested on September 29, 1999 and graded within the following categories: sizes-1.88-2 inches, 2-2.3 inches, 2.3-2.8 inches, 2.8-3 inches, 3-3.9 inches; roughs; knobs; cracks; sunburn; and scab. Data for each category was collected by both weight and number of tubers per treatment.

Data was subjected to an analysis of variance and means separated using the LSD test at P=0.05. Each of the 4 varieties were analyzed as separate trials.

To further determine if potatoes planted into Muster treated soil affected yields and quality, a large field scale trial was conducted. A grower planted Russet Burbank, Russet Norkotah, Gold Rush, and Shepody potatoes into both Muster treated soil and Muster free soil. Muster + Agral 90 had been applied at 15 g/ha + 0.2%v/v the previous spring to Canola. Yields were collected from 8 random locations within each variety on both Muster treated and Muster free soils. Ten foot sections of rows were harvested and potatoes graded into categories as listed above.

Results and Discussion

Normal grower practice would be to apply Muster to Canola approximately 10 months before planting potatoes, but in the interest of generating data sooner, plots were sprayed with Muster in the fall of 1998 (November 23) and planted to potatoes 6 months later in the spring of 1999. Otherwise data collection would have taken another year if plots were sprayed in the spring of 1999 and not replanted to potatoes until the spring of 2000. It is important to realize however, that injury ratings from Muster applied the previous fall would be expected to be higher than if Muster was applied the previous spring as per normal grower practice.

Crop Injury. The effect of recropping to potatoes following Muster application will be discussed on a potato variety basis for the small plot research trials.

1. Superiors. Crop injury from Muster + Agral 90 applied at 20 g/ha + 0.2 % v/v was only significantly higher than the untreated control at the first rating (June

24). At this time injury was 14% (Table 1). By July 22 injury was reduced to 10%, and by the final rating on August 31 injury was further reduced to 4% (Table 1).

Crop injury from Muster + Agral 90 applied at 40 g/ha + 0.2% v/v (2x normal rate) was significantly higher than the untreated control and Muster + Agral 90 (20 g/ha + 0.2% v/v) rate at the June 24 (75%), and July 22 (40%) rating dates (Table 1). At both dates, the 2x Muster rate resulted in more than 2x the injury of the 1x rate. Injury at the June 24 rating resulted in delayed emergence and small leaves on emerged plants. Injury on July 22 was in the form of a general stunting of the plant with smaller and shorter stems and leaves.

At the final rating collected on August 31, potatoes recovered from the high early injury levels. At this time injury was reduced to 9% and was not significantly different from the untreated control or Muster + Agral 90 - 20 g/ha + 0.2% v/v rate (Table 1). Injury at this time was a slight reduction in height and slightly smaller stem diameter.

Overall, injury from the 1x Muster application rate of 20 g/ha was considered acceptable from mid-season onward. Injury from the 2x Muster application rate of 40 g/ha was exceptionally high until late in the growing season. By this time, the potatoes recovered to an acceptable level, however.

2. Atlantics. The only rating date that resulted in crop injury significantly higher than the untreated control from either Muster + Agral 90 rates was the June 24 rating date. Injury at this time was 34% from the Muster + Agral 90 (20 g/ha + 0.2% v/v) rate and 75% from the 2x Muster + Agral 90 (40 g/ha + 0.2% v/v) rate (Table 2). As the season progressed, injury was still visible from both rates, but was not significantly different from the untreated control. By the final rating, crop injury from the Muster + Agral 90 (20 g/ha + 0.2% v/v) was 8% and from the Muster + Agral 90 (40 g/ha + 0.2% v/v) rate 15% (Table 2). Differences were not significant however.

3. Shepody's. Shepody potatoes were very tolerant to the 1x Muster + Agral 90 (20 g/ha + 0.2% v/v) rate throughout the season, as injury never exceeded 6% (Table 3). By the final rating (August 31) no injury was observed. Injury from the Muster + Agral 90 2x rate (40 g/ha + 0.2% v/v) was less on Shepody than that observed on Superior or Atlantics. Early season injury (June 24) was 20%, mid season injury (July 22) was 29%, and late season injury was 8% (Table 3). Injury from Muster at both rates was less obvious as the season progressed.

Overall Shepody potaoes were considered tolerant to normal (1X) Muster application rates and recovered to acceptable levels from the 2x rate as the season progressed.

Table 1. Crop injury and yields for Superior

Treatment	Product Rates	Crop Injury (0-100%) June 24	July 22	Aug. 31	Total # tubers per treat.	Total Yield (cwt/acre)	Marketable # tubers per treatment	Marketable Yields (cwt/acre)
Untreated control	0	0 c**	0 b	0	178 a	221.4 a	115 a	180.6 a
Muster + Agral 90	20 g/ha + 0.2% v/v	14 b	10 b	4	145 b	189.3 a	88 ab	149.7 ab
Muster + Agral 90	40 g/ha + 0.2% v/v	75 a	40 a	9	98 c	121.2 b	51 b	84.1 b
	LSD*	7	25	N.S. (1)	30	50.7	47.1	70.5

* Least Significant Difference

** means followed by the same letter within a column are not significantly different from each other (LSD 5%)

(1) Not Significant

Table 2. Crop injury and yields for Atlantic

Treatment	Product Rates	Crop Injury (0-100%) June 24	July 22	Aug. 31	Total # tubers per treat.	Total Yields (cwt/acre)	Marketable # tubers per treatment	Marketable Yields (cwt/acre)
Untreated control	0	0 c**	0	0	173	214.0	87	153.4
Muster + Agral 90	20 g/ha + 0.2% v/v	34 b	23	8	142	174.4	72	126.2
Muster + Agral 90	40 g/ha + 0.2% v/v	75 a	20	15	145	167	77	121.2
	LSD*	26	N.S. (1)	N.S.	N.S.	N.S.	N.S.	N.S.

* Least Significant Difference

** means followed by the same letter within a column are not significantly different from each other (LSD 5%)

(1) Not Significant

4. Russet burbanks. Russet Burbank potatoes were also very tolerant to the 1x Muster + Agral 90 (20 g/ha + 0.2% v/v) rate throughout the season, as injury never exceeded 5% (Table 4). By the final rating (August 31), no injury was observed.

Table 3. Crop injury and yields for Shepody

Treatment	Product Rate	Crop Injury (0-100%)			Total # tubers per treat.	Total Yields (cwt/ acre)	Marketable # tubers per treatment	Marketable Yields (cwt/acre)
		June 24	July 22	Aug 31				
Untreated control	0	0 b**	2 b	0 b	150	185.6 a	43 a	86.6
Muster + Agral 90	20 g/ha + 0.2% v/v	4 b	6 ab	0 b	151	190.5 a	29 ab	82.9
Muster + Agral 90	40 g/ha + 0.2% v/v	20 a	29 a	8 a	130	150.9 b	18 b	52.0
	LSD*	13	N.S. (1)	4	N.S.	32.2	16	N.S.

* Least Significant Difference

** means followed by the same letter within a column are not significantly different from each other (LSD 5%)

(1) Not Significant

Table 4. Crop injury and yields for Russet Burbank

Treatment	Product Rates	Crop Injury (0-100%)			Total # tubers per treat.	Total Yields (cwt/ acre)	Marketable # tubers per treatment	Marketable Yields (cwt/acre)
		June 24	July 22	Aug. 31				
Untreated control	0	0 b**	2	0 b	184	222.7	24	58.0
Muster + Agral 90	20 g/ha + 0.2% v/v	5 ab	3	0 b	188	230.1	41	84.6
Muster + Agral 90	40 g/ha + 0.2% v/v	13 a	25	8 a	154	215.2	28	59.4
	LSD*	10	N.S. (1)	3	N.S.	N.S.	N.S.	N.S.

* Least Significant Difference

** means followed by the same letter within a column are not significantly different from each other (LSD 5%)

(1) Not Significant

Injury from the Muster + Agral 90 2x rate (40 g/ha + 0.2% v/v) was less than that observed on Superior and Atlantics, and similar to that observed on Shepody. Early season injury (June 24) was 13%, mid season injury (July 22) was 25%, and late season injury was 8% (Table 4).

Overall Russet Burbank was considered tolerant to normal 1X Muster application rates and recovered to acceptable levels from the 2x rate as the season progressed.

Total Yields. Analysis of total yields indicated that statistically none of the potato varieties replanted into soil treated with Muster + Agral 90 at 20 g/ha + 0.2% v/v the previous fall, resulted in yields significantly different from the untreated Muster free control (Tables 1-4). Shepody and Russet Burbank varieties actually had slightly higher total yields than the untreated control plots (Tables 3 and 4). Superior and Atlantic varieties resulted in somewhat lower total yields, but were not significantly lower than the untreated control (Tables 1 and 2).

Analysis of total yields from the potatoes varieties planted into soil treated with 2x the normal Muster + Agral 90 rate (40 g/ha + 0.2% v/v) the previous fall indicated that yields as compared to the untreated control were reduced, but not always significantly.

Russet Burbank and Atlantic varieties planted into soil treated with 2x Muster application rates resulted in lower yields than those collected from the untreated plots, but differences were not considered significantly different (Tables 2 and 4). Superior and Shepody yields were considered significantly lower than those collected from the Muster free (untreated check) plots however (Tables 1 and 3).

Total yield differences could be accounted for mostly through differences in the total number of tubers per plot (tables 1-4). Only Superior total potato numbers per plot resulted in significantly lower numbers than the untreated control at both Muster rates (Table 1).

Marketable Yields. Marketable yields were much lower a percentage of total yields than expected for all varieties. For example, the untreated control marketable yield for Superior was 81.6% of total yields, for Atlantic 71.7%, for Shepody's 46.7%, and for Russet Burbank only 26%. The longer season varieties (Shepody and Russet Burbank) were affected more than the early to mid season varieties of Superior and Atlantic. Marketable yields were low as a result of a large number of small potatoes and also sunburning. Moisture stress at critical times of the growing season were responsible for the number of small potatoes, and the early diedown of potato tops as the result of some moisture stress would have provided increased exposure to sunlight, and as a result more sunburning.

Analysis of marketable yields from potatoes planted into soil treated with Muster + Agral 90 at 20 g/ha + 0.2% v/v the previous fall, indicated that yields were lower than the untreated control when Superior, Atlantic and Shepody potatoes were replanted and higher when Russet Burbank were planted. Differences were not considered statistically different however (Tables 1-4).

Analysis of marketable yields from potato varieties planted into soil that had been treated with 2x the normal Muster + Agral 90 rate (40 g/ha + 0.2% v/v) the previous fall indicated that yields were lower on Atlantic and Shepody varieties, and slightly higher on Russet Burbank potatoes. Differences were not considered statistically different, however (Table 1-4). Only Superior potatoes had yields significantly lower than the untreated control (Table 1).

In general, treatments which had the highest yields, also had the highest number of marketable potatoes per treatment (Tables 1-4).

Additional Data. Additional data collected per potato variety included: weight of potatoes; size of potatoes based on the following categories: 1.9 to 2", 2 to 2.3", 2.3 to 2.8", 2.8 to 3", 3 to 3.9"; roughs; knobs; cracks; sunburn; scab; hollow heart; brown center; and marketable yields. For each of these categories the number of potatoes and the weight of potatoes were calculated. Data for all these categories are not presented but are available upon request.

In general there were not many significant differences in the categories listed above. The only categories where differences existed between the untreated control and the normal Muster + Agral 90 rate (20 g/ha + 0.2% v/v) that are not presented in the tables were: 1) on Superior there were a significantly higher number of potatoes within the untreated control plots at the 2 to 2.3 inch size category as compared to the normal Muster; 2) on Atlantic potatoes, there were significantly more sunburnt potatoes in the untreated controls as compared to the normal Muster application rate; 3) on Russet Burbank's the normal Muster application rate had a significantly higher number of potatoes and weight within the potato size 2 to 2.3 inch category than that found in the untreated control plots.

Differences within all the categories for which data was collected across the four potato varieties was therefore considered minor and further supported that differences between the normal Muster application rate and the untreated control was minimal, and in most instances not significant.

When evaluating the 2x Muster application rate there were a few significant differences among the potato size categories, as compared to the untreated, but no other significant reduction in the quality parameters measured.

Grower Field Scale Trial. Four different potato varieties, Shepody, Russet Burbank, Russet Norkotah, and Gold Rush were planted into a field that had been planted to Canola and treated with Muster + Agral 90 at 15 g/ha + 0.2% v/v the previous year. For comparison the same varieties were also planted into a different field that was not planted to Canola or treated with Muster the previous year.

Results indicated that there was very little difference when comparing number of stems per plant or number of tubers per plant within the varieties planted into Muster treated soil versus Muster-free soil (Table 5). Evaluation of total yields and marketable yields revealed that some differences existed depending upon the variety. Differences between Shepody and Gold Rush potatoes planted on Muster treated soil or Muster-free soil was considered minor. Russet Burbank total and marketable yields actually increased where they were planted into soil that had been treated with Muster the previous year (Table 5). The only variety to result in a major total and marketable yield reduction following planting into Muster treated soil was Russet Norkotah (Table 5).

Russet Norkotah forms a small potato plant, does not tolerate stress well, and is not very competitive. Last summer, conditions at the site were dry up until early August. As a result, Russet Norkotah's were negatively impacted and a poor root system developed, which also resulted in early down die. Number of plants and stem numbers were therefore not collected as data was collected late in the season. This was also the only variety which had a large number of volunteer Canola plants present. With small potato plants present, more light was able to reach the soil and as a result volunteer Canola was able to germinate and compete with the potatoes. As a result, much of the Russet Norkotah yield reduction could be attributed to the competition effect of the volunteer Canola and not to Muster carry over.

Data was also collected, but not reported for the breakdown of yields for size categories (1.875 inches); (1.875 to 2.0 inches); (2.0 to 2.25 inches); (2.25 to 2.5 inches); (2.5 to 2.75 inches);(2.75 to 3 inches);(3 to 3.5 inches); and (3.5 inches). Number of tubers and weights were collected for each of these categories and are available upon request. Potato varieties at each site were also evaluated for the occurrence of rough, hollow heart, and scab. No rough, hollow heart, or scab, was observed on any of the varieties evaluated in this trial.

Over all it was felt that Muster carryover was not a factor for the 1999 season when evaluating the effect of planting potatoes into soil which had been treated with Muster the previous year.

Table 5. Yield results and number of stems and tubers per plant from the grower field scale trial

Potato variety	Muster applied Previous year	# stems /plant	# tubers/ plant	Total yields cwt/acre	Marketable yields cwt/acre
Shepody	No	3.25	5.72	197.3	176.1
Shepody	Yes	3.12	7.41	209.3	181.3
Russet Burbank	No	3.97	12.14	213.7	139.4
Russet Burbank	Yes	4.15	13.96	261.3	156.7
Russet Norkotah	No	N/A	N/A	188.2	154.8
Russet Norkotah	Yes	N/A	N/A	134.8	96.22
Gold Rush	No	3.4	10.45	223.6	183.1
Gold Rush	Yes	3.62	9.03	211.2	175.3

Conclusions

Russet Burbank and Shepody potatoes were considered the most tolerant to Muster + Agral 90 applied at the normal 20 g/ha + 0.2% v/v rates in the small plot research trials. Visual injury at this rate never exceeded 6% on either variety, and injury was never significantly different from the untreated controls. Superior and Atlantic potato varieties tended to be more sensitive from the early to mid season part of the summer but recovered to acceptable levels as the season progressed. Injury was significantly higher than the untreated control at the first rating on both Superior and Atlantic varieties, but by late season (Aug. 31) differences were not considered statistically significant.

Analysis of total yields indicated that statistically none of the potato varieties replanted into soil treated with Muster + Agral 90 at 20 g/ha + 0.2% v/v the previous fall, resulted in yields significantly different from the untreated Muster free control. Shepody and Russet Burbank varieties actually had slightly higher total yields than the untreated control plots. Superior and Atlantic varieties resulted in somewhat lower total yields, but were not significantly lower than the untreated control.

Analysis of marketable yields indicated that although yields from Muster + Agral 90 applied at the normal 20 g/ha + 0.2% v/v rate was lower than the untreated control for Superior, Atlantic, and Shepody varieties, and higher than the untreated control for Russet Burbank potatoes, differences were not considered statistically different. Marketable yields were therefore not statistically influenced by normal Muster application rates on the potato varieties evaluated.

Overall, based on final crop injury ratings, total yields, and marketable yields from the small plot research it was found that Superior, Atlantic, Sheopody, and Russet Burbank potatoes were considered tolerant when planted into soil treated with Muster + Agral 90 at 20 g/ha + 0.2% v/v the previous fall. It is also important to note that the registered rate of Muster for the Maritimes is 15 g/ha so tolerance should be even greater at this lower rate.

Muster + Agral 90 applied at 2x the normal rate (40 g/ha + 0.2% v/v) resulted in more than 2x the injury than that observed from the 1x rate in most instances. As was experienced with the normal 1x Muster rate, Superior and Atlantics tended to be more sensitive than Shepody and Russet Burbank varieties early in the season. Injury from the 2x rate on June 24 on both Superior and Atlantics were 75%, while on Shepody and Russet Burbank it was 20% and 13% respectively. As the season progressed differences were not as obvious. By the final rating (August 31) injury was 15% on Atlantic, 9% on Superior, and 8% on both Shepody and Russet Burbank varieties. It appears that 2x rates will effect potato variety development early in the season, but varieties tend to recover as the season progresses.

Overall, all potato varieties suffered a total yield reduction as a result of the Muster + Agral 90 2x rate (40 g/ha + 0.2% v/v), but the extent of the reduction was variety dependent. Atlantic and Russet Burbank yield reductions were not considered significantly different from the untreated controls. Superior and Shepody yields were significantly lower than the untreated control however.

The only variety whose marketable yields were significantly lower than the untreated control from the 2x Muster + Agral 90 (40 g/ha + 0.2% v/v) was Superior. Muster at the 2x rate did not statistically reduce marketable yields on Atlantic, Shepody or Russet Burbank varieties.

Overall potatoes were more sensitive to the higher Muster rate. Crop injury ratings were higher, and total yields and marketable yields were lower than the untreated control. Although crop injury was higher and total and marketable yields lower from Atlantic and Russet Burbank varieties, they were not significantly different from the untreated control. Shepody marketable yields were also not significantly different from the untreated control. Superiors were the most sensitive variety and may be at risk for yield reductions if 2x Muster rates result from over application. Caution should likely be exercised when planting other early season potatoes as well.

Results from the large field scale trial also confirmed potato tolerance to Muster herbicide carryover when applied at 15 g/ha rates the year previous to planting potatoes. Shepody, Russet Burbank, and Gold rush varieties all were considered very tolerant and total and marketable yield differences between the untreated control and the treated was considered minor. Russet Norkotah yields were much lower than the untreated control but were the result of competition from volunteer Canola and not Muster carryover.

Acknowledgements

Appreciation is extended to Gerald Springer for providing the site for the small plot research trials and for his cooperation during the trial. Appreciation is also extended to Janet McLaughlin NBDARD, and to Jacques Lavoie's (NBDARD) summer crew for their assistance.

DIFFERENCES IN STORAGE QUALITY BETWEEN ELEVEN RUSSET BURBANK CLONES

DIFFÉRENCES DANS LA QUALITÉ DE CONSERVATION DE ONZE CLONES DE RUSSET BURBANK

Warren K. Coleman[1], David Wattie[2], Xiu Q. Li[1], Esther Tremblay-Deveau[1] and/et Shirlyn E. Coleman[2]

Abstract: A two year study was undertaken to evaluate storage quality of eleven 'Russet Burbank' clones grown at Fredericton, New Brunswick. Clonal differences were detected for both sucrose and glucose levels in tubers during storage at 4 and 10 degrees Celsius after three months in storage. Although absolute glucose levels after 10 degrees Celsius storage varied from year to year, there were similar trends among the clones. Best processing clones (low glucose) after three month's storage over the two year period were, in decreasing order of importance, Heany, Graham's Road, Idaho D, PEI2 and Colorado. The British Columbia, Idaho E and NB2 clones were the worst in terms of internal tuber glucose levels. Preliminary data suggests that the year to year variability may be a reflection of the chemical maturity of the tubers at harvest.

Résumé : Une étude de deux ans a été réalisée pour établir la qualité de conservation de onze clones de Russet Burbank cultivés à Fredericton (Nouveau-Brunswick). Des différences clonales ont été relevées dans les concentrations de sucrose et de glucose des tubercules conservés pendant trois mois à 4 °C et à 10 °C. Les concentrations absolues de glucose après un entreposage à 10 °C variaient d'une année à l'autre, mais les tendances se répétaient parmi les clones. Les meilleurs clones pour la transformation (faible concentration de glucose) après trois mois de conservation sur deux ans étaient, par ordre d'importance décroissant, Heany, Graham's Road, Idaho D, PEI2 et Colorado. Les clones British Columbia, Idaho E et NB2 auraient les pires taux de glucose dans les tubercules. Les données préliminaires indiqueraient que la variabilité d'une année à l'autre pourrait dépendre de la maturité chimique des tubercules à la récolte.

Introduction

Natural mutations in clonally propagated potato (*Solanum tuberosum* L.) varieties have led to numerous apparent strains. Although an initial study indicated no differences in visual or agronomic characteristics among five Russet Burbank clones (Wright and Mellor, 1976), subsequent work demonstrated significant variation among ten clones (Love *et al.,* 1992). Love and his co-workers noted that considerable intravarietal improvement could rapidly result from effective selection and screening procedures.

Although Russet Burbank is a major processing variety in North America, no study has examined the available clones for processing quality. The use of glucose content in tubers is recognized as a valid criteria for determining processing quality (Coleman and Tai, 1999) with glucose levels of 0.035% (FW basis) or less indicating high quality processing varieties (Sowokinos and Preston, 1988). Consequently, eleven Russet Burbank clones were examined for their response to storage temperature during the 1998-1999 and 1999-2000 seasons.

---

[1] Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, NB E3B 4Z7 / Centre de recherches sur la pomme de terre, Agriculture et Agro-alimentaire Canada, C.P. 20280, Fredericton, NB E3B 4Z7

[2] Potato and Horticultural Branch, NBDARD, Fredericton, NB E3B 5H1 / Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

Materials and Methods

Tubers from eleven clones of Russet Burbank were produced in 1998 and 1999 at the Potato Research Centre, Agriculture and Agri-Food Canada in Fredericton New Brunswick on a loam soil. Original seed for both years were obtained from the Bon Accord Elite Seed Potato Centre and consisted of the following clones: New Brunswick 1 (NB1), British Columbia (BC), Colorado (C), New Brunswick 2 (NB2), Graham's Road (GR), Heany (H), Idaho D (ID), Idaho E (IE), Manitoba (M), PEI1 (P1) and PEI2 (P2). Seed from all clones were handled and stored under identical conditions. Seed pieces for planting were cut to 30 +/-g fresh weight each.

A randomized complete block design gave 11 treatments and 6 repetitions. At planting 1000 kg/ha of 17:17:17 + 2% Magnesium was applied to each plot. The seed spacing was 12 inches (25.4 cm) with 14 rows (including guard rows) on 3 foot (0.9 m) centres and a row length of 25 feet (6 m) for each plot. Fungicide (Bravo) and insecticide (Novadon, Amine) were applied as needed. Diathane was used as an alternative fungicide.

After skin set at 14 degrees Celsius for approximately two weeks, the harvested crop was stored at 4 or 10 degrees Celsius. Sucrose and glucose levels in tubers were determined after three months (January 1999 and January 2000) in storage (Coleman et al., 1993; Coleman et al., 1996) using a YSI biochemical analyzer (Model 2700 Select; Yellow Springs Instrument Co., Inc., Yellow Springs, OH). Sucrose was expressed as a Sucrose Rating (SR; mg sucrose/g FW tuber) while glucose was expressed as percentage glucose on a FW basis.

Figures were prepared with SigmaPlot version 5.0 and included vertical standard error bars as a measure of data dispersion.

Results

During the 1998-1999 and 1999-2000 storage seasons, clonal differences were observed in sucrose levels after three months of storage at 4 or 10 degrees Celsius. As expected, the sucrose levels were greater at 4 degrees Celsius than at 10 degrees Celsius storage. However, there were no consistent trends among the clones from year to year (data not shown).

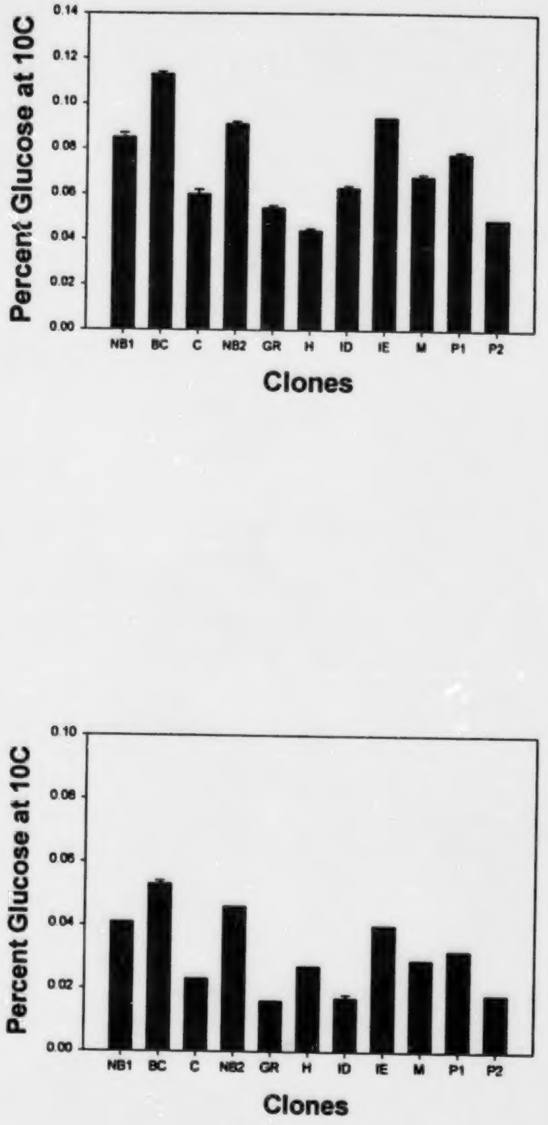


Figure 1. Tuber glucose levels in eleven Russet Burbank clones after three months of storage at 10C during the 1998/1999 (upper graph) and 1999/2000 (lower graph) storage seasons. Vertical bars represent +/- SE.

Glucose levels were on average 10-fold greater in tubers stored at 4 than 10 degrees Celsius. Clonal differences were also apparent in 4 and 10 degrees Celsius stored tubers although consistency from year to year was only exhibited at 10 degrees Celsius (Figure 1). The storage season of 1999-2000 produced better processing material than the 1998-1999 season. Since the storage temperature of 10 degrees Celsius would provide tubers appropriate for processing, clones were ranked from good (low glucose) to bad (high glucose) processors. Best processing clones (low glucose) after three month's storage over the two year period were, in decreasing order of importance, Heany, Graham's Road, Idaho D, PEI2 and Colorado. The British Columbia, Idaho E and NB2 clones were the worst in terms of internal tuber glucose levels.

Conclusions

Although Russet Burbank has been recognized as a variety since 1914, no distinct strains have been selected and characterized by the processing industry. However, the absence of intravarietal selection has not prevented the process of somatic mutation from occurring. This process has led to an informal collection of clones within seed programs. An initial study (Wright and Mellor, 1976) suggested that five clones of Russet Burbank were similar in plant and tuber characteristics as well as total yield. However, a more detailed study (Love et al., 1992) indicated that a New Brunswick clone was "markedly inferior" when grown under conditions found in Aberdeen, Idaho.

The present study demonstrated that clonal differences for both sucrose and glucose levels in tubers during storage at 4 or 10 degrees Celsius occurred after three months in storage. There were similar glucose trends among the clones during the two-year study although absolute glucose levels after 10 degrees Celsius storage varied from year to year. This yearly variation may be due to differences in the maturation rates of the clones during the preceding fall. Future work will examine tuber shape, chemical maturation and relative stability in soluble sugar levels during pre-harvest and post-harvest storage, including reconditioning capacity and long term storage effects.

The Russet Burbank clones derived from Maritime potato programs, i.e., Heany, Graham's Road and PEI2, may provide a higher quality processing product than tubers derived from other clones when grown in New Brunswick potato production areas. However, future work will be necessary to confirm this suggestion.

References

Coleman, W.K., G.C.C. Tai, S. Clayton, M. Howie and A. Periera. 1993. A portable monitor for the rapid assessment of processing quality of stored potato tubers. *American Potato Journal* **70**: 909-923.

Coleman, W.K., J. LeBlanc and T. Morishita. 1996. A rapid test for chemical maturity monitoring of tubers. *American Potato Journal* **73**: 501-507.

Coleman, W.K. and G.C.C. Tai. 1999. Comparative performance of three test methods for determining chipping quality in tubers of potato (*Solanum tuberosum* L.). *Canadian Journal of Plant Science* **79**: 625-632.

Love, S.L., A.L. Thompson, T.P. Baker and D.L. Corsini. 1992. Comparison of Russet Burbank clones from various geographical regions of the United States and Canada. *American Potato Journal* **69**: 299-307.

Sowokinos, J.R. and D.A. Preston. 1988. Maintenance of potato processing quality by chemical maturity monitoring (CMM). Minnesota Agricultural Experiment Station Bulletin 586-1988. pp.1-11.

Wright, N.S. and F.C. Mellor. 1976. A comparison of five clones of virus-free Netted Gem potato from British Columbia and Idaho. *American Potato Journal* **53:** 99-103.

POST HARVEST TEST FOR DORMANT TUBERS

CONTRÔLE APRÈS RÉCOLTE POUR TUBERCULES DORMANTS

Mathuresh Singh[1]

Abstract: Several test conditions for the simultaneous detection of potato leafroll (PLRV) and potato virus Y (PVY) in dormant tubers and leaves by reverse transcription – polymerase chain reaction (RT-PCR) were optimized. Various factors optimized at the reverse transcription (RT) stage rather than at the amplification (PCR) stage affected the outcome. Two-fold dNTP's concentration (1.0mM) is required during RT to yield distinct bands of PLRV and PVY in duplex PCR in comparison to 1- fold dNTP's (0.5mM) for the simplex PCR. Various proportions of antisense primers of PLRV and PVY used during RT affected subsequent duplex RT-PCR. Optimal amplification of both viruses were obtained at a ratio of 0.90:0.49uM of PLRV:PVY antisense primers. Similarly, in the multiplex PCR oligo dT:PLRV antisense primer (1.0uM:0.65uM) at RT stage amplified distinctly PVY, PLRV, PVS/PVM viruses with a primer combination of oligo dT 1.0uM, PVY sense primer 1.0uM, Carla uni 0.4uM and PLRV antisense and sense primer 0.4um at the PCR stage. An interaction of dNTP's and RNA template concentration was observed. A higher concentration of RNA was required at the one-fold dNTP's concentration than at 2-fold dNTP's. Application of optimized conditions to singly- and doubly- infected tubers detected both PLRV and PVY from naturally infected field grown tubers. Similarly, multiplex RT-PCR detected PVY, PLRV, PVM/PVS from naturally infected plants, but its application to dormant tubers need extensive lab and field evaluation.

Resume: Plusieurs conditions de test pour la détection simultanée du virus enroulement (PLVR) et le virus Y (PVY) dans les tubercules dormants et les feuilles en transcription reverse – la réaction en chaîne catalysée par la polymerase (RT-PCR) fût optimisé. Plusieurs facteurs se sont optimisées au stage ou la transcription reverse (RT) s'est produite au lieu du stage d'amplification (PCR) ce qui a affecté le résultat. Une concentration double de dNTP's (1.0mM) est requise durant le stage RT pour produire les bandes distinctes du PLRV et du PVY pour le duplex PCR en comparaison avec la concentration simple de dNTP's (0.5mM) pour le simplex PCR. De différentes proportions des primeurs antisense de PLRV et de PVY utilisé durant le stage RT ont affecté les subséquents duplex RT-PCR. L'amplification optimale des deux virus a été obtenue à une proportion de 0.90:0.49uM des primeurs antisense PLRV:PVY. Aussi, dans le multiplex PCR oligo dT:PLRV primeur antisense (1.0uM:0.65uM) au stage RT a amplifié distinctement les virus PVY, PLRV, PVS/PVM avec une combinaison de primeurs d'oligo dT 1.0uM, PVY sense primeur 1.0uM, Carla uni 0.4uM et PLRV antisense et sense primeur 0.4um au stage PCR. Une interaction du dNTP's et de la concentration du modèle RNA a été observée. Une concentration élevée de RNA a été requise pour la concentration simple du dNTP's comparé à la concentration double du dNTP's. L'application des conditions optimes aux tubercules infectés simplement et doublement a detecté les deux virus PLRV et PVY des tubercules qui étaient infecté naturellement dans le champs. Aussi, le multiplex RT-PCR a detecté le PVY, PLRV, PVM/PVS des plantes infectées naturellement, mais son application aux tubercules dormants a besoín de beaucoup plus d'évaluation au laboratoire et au champs.

Introduction

New Brunswick has consistently remained Canada's largest exporter of seed potatoes into international markets for several years. However, other provinces such as Alberta and Saskatchewan have steadily increased production and export in the last few years. Virus levels have increased in recent years all over North America. This increase is mostly due to the planting of seed with high levels of virus inoculum and subsequent spread during the growing season. Since

---

[1] Agricultural Certification Services Inc. / N.B. Potato Agency, Comp. 17, 385 Wilsey Road, Fredericton, NB E3B 5N6 / Agricultural Certification Services Inc. / Agence de la pomme de terre du Nouveau-Brunswick, comp. 17, 385, chemin Wilsey, Fredericton, NB E3B 5N6

Canadian seed certification process is based on visual inspection, current season infection often goes undetected. This of course, will continue until there is a post-harvest test available to assess virus levels in dormant tubers prior to the sale and shipment of seed potatoes.

Florida test and laboratory tests (such as ELISA) have served NB growers well over the years, but both of these tests require tubers which have had their dormancy broken. Florida test results are usually not available until the end of January, which is too late for most offshore markets.

Potato leaf roll virus (PLRV) and potato virus Y (PVY) are the two most economically important viruses affecting potato crops throughout the world (Beemster and Rozendaal, 1972). In the last five years several tests based on nucleic acid detection systems such as nucleic acid spot hybridization (NASH) (Singh and Singh, 1995) and reverse transcription- polymerase chain reaction (RT-PCR) (Singh and Singh, 1996) have been reported for the detection of individual viruses from dormant tubers. A duplex RT-PCR system for the simultaneous detection of PLRV and PVY in aphids was reported by Singh *et al.*(1996).

The major objective of this project was to evaluate duplex RT-PCR system reported by Singh *et al.* 1996 for the use of simultaneous detection of PLRV and PVY from dormant tubers. Also, to develop this technique to the point that it could be used reliably on a large numbers of tuber lots and at a reasonable cost. Therefore, a systematic study was initiated to determine the parameters, which affect the performance and reproducibility of the duplex RT-PCR test. At the same time, the possibility was also explored to incorporate more viruses to develop a multiplex PCR system to reduce the cost.

Materials and Methods

Production of PVY and PLRV Infected Tubers. Healthy plantlets of cvs. Russet Burbank and Shepody were obtained from the Plant Propagation Centre, Fredericton, NB. They were planted in greenhouse and inoculated mechanically (PVY) and with aphids (PLRV) fed on a known source of leafroll. The inoculated plants were tested for PVY and PLRV with ELISA at 10-day intervals to monitor the concentration of viruses. Once infection was established, PVY infected plants were grafted with PLRV infected scion and vice-versa. Grafted plants were tested for PVY and PLRV infection and tubers were harvested at maturity.

Potato tubers of cultivars (cv) Russet Burbank, Russet Norkotah, Red Pontiac, and Shepody, all singly or doubly infected with PVY and PLRV under field conditions were also collected and used.

Selection and Synthesis of Primers. A) Duplex PCR. The PLRV sense primer: 5'-CGC GCT AAC AGA GTT CAG CC-3' was homologous to nucleotides 3670-3689 and the antisense primer: 5'-GCA ATG GGG GTC CAA CTC AT-3' was complementary to nucleotide 4005-3986. The amplified product was 336bp (Singh et al., 1995). The PVY sense primer 5'-ACG TCC AAA ATG AGA ATG CC-3' was homologous to nucleotide 8717-8736 and antisense primer: 5'-TGG TGT TCG TGA TGT GAC CT-3' was complementary to nucleotide 9196-9177. The amplified product was 480bp (Singh *et al.*, 1996).

B) Multiplex PCR. The common antisense primers oligo (dT): 5'-TTT TTT TTT TTT TTT TTT TTT A-3'; 5'-TTT TTT TTT TTT TTT TTT TTT C-3 and 5'-TTT TTT TTT TTT TTT TTT TTT-3' were mixed together and used for cDNA synthesis (Pappu et al., 1993). In conjunction with oligo (dT), Carla-uni primers : 5'- GGA GTA ACC GAG GTG ATA CC-3' and 5'-GGA GTA ACT GAG GTG ATA CC-3' (Badge et al., 1996), were used as sense primer for PVM/PVS amplification. Leafroll primers and PVY sense primer were the same as described for duplex PCR. The combination of oligo dT as antisense primer and carla uni as sense primer amplified a product of 188 bp for PVM /PVS, where as oligo dT and PVY sense primer gave a product of 900bp.

RNA Isolation from Leaves, Plantlets, and Tubers. RNA was extracted from leaves, plantlets, and tubers using proteinase K method as described by Singh and Singh (1996). RNA obtained from 150 - 200ul of sap was dissolved in 100ul (tubers) and 1000ul (leaves and plantlets) of sterile water and designated as stock solution. Further dilutions for reverse transcription were made form this stock

Composite Samples of Infected and Healthy Sap. A series of dilutions (1:2, 1:5, 1:10, 1:20, 1:40, 1:60, 1:100, 1:200, 1:400, 1:600, and 1:1000) were made by mixing tuber sap from infected and healthy. Nucleic acids were extracted from 200ul of sap. Control samples of healthy, infected, and buffer were always included in each test.

Evaluation of Various Factors at Reverse Transcription (RT) Stage. 1. Optimization of dNTP's concentration. Three different concentrations (0.5, 1.0, 1.5mM) of dNTP's were tested in single, duplex, and multiplex during RT to synthesize cDNA.

2. Optimization of antisense primers. Antisense primers for PLRV and PVY were tested in six different combinations in duplex PCR. They were: 0.28:1.10; 0.41:0.97; 0.70:0.70; 0.83:0.56; 0.90:0.49; and 0.97:0.41 (uM). However, only two combinations 0.65:0.4 and 0.65:1.0uM (LR: Oligo dT) were tested in the multiplex PCR.

3. Optimization of RNA template. RNA template dilutions of 1:20, 1:100, 1:200, and 1:300 were made from the stock solution. The remaining reagents for reverse-transcription contained in the final solution were 50mM Tris-HCl, pH8.3, 75mM KCl, 10mM DTT, 3mM $MgCl_2$, 10U of RNasin (Promega), and 100U of reverses-transcriptase (M-MLVRT, Givco BRL, Life Technology Gaithersburg, MD). Reverse transcription samples (10ul) were incubated at room temperature for 20 minutes, transferred to 42°C for 1 to 1.5 hr for RT and the reaction was stopped by heating to 95°C for 2-3min.

Optimization of Various Factors during Polymerse Chain Reaction (PCR). In duplex PCR, aliquots of 4ul of the RT reaction were added to 21ul of PCR mixture for amplification. Both antisense and sense primers of PLRV were used at 0.21uM each and PVY at 0.35uM each, which is different from those used for cDNA synthesis. This was determined by testing primer concentrations at three ratios (PVY:PLRV 0.28:0.28; 0.21:0.35; 0.35:0.21uM) of both PVY and PLRV primers.

In multiplex PCR oligo dT primer mix was used at 1.0uM concentration as antisense primer for PVY and PVS. The sense primers were tested at two different concentrations as follows: PVY (0.625 and 1.0uM); PVS (0.40uM); and PLRV (0.375 and 0.4uM).

The final concentration of the remaining reagents for both PCR's were: 10mM Tris-HCl, pH 8.3, 50mM KCl, 2.5 mM $MgCl_2$, 0.2mM each dNTP, 0.625U of Amplitaq DNA polymerase (Perkin-Elmer). Additionally, dNTP concentrations of 1.0 and 1.5mM and Amplitaq concentrations of 2.5U were tested for duplex PCR. Samples were placed in 0.2ml strip tubes (Sarstedt) and amplified in 30 cycles using a Peltier Thermal cycler (MJ Research). Each cycle consisted of 1 min. each of denaturation (94°C), annealing (57°C), extension (72°C), and final extension of 10min. (72°C). In some tests an annealing temperature of 60°C and polymerase extension time of 2 min. per cycle were evaluated. 10ul of amplification mix was electrophoresed on 1.5% agarose gel containing 0.5mg/ml ethidium bromide and photographed under UV illumination. A positive and a negative virus control and a PCR reaction mix without template were always included.

Greenhouse Evaluation. One hundred and ninety tubers from a heavily (over 90%) and a similar numbers of tubers from a lightly (less than 5%) PLRV and PVY infected lots of Russet Burbank were tested by duplex PCR in the laboratory. One piece from each tuber was removed and planted in the greenhouse for visual and leaf test comparison.

Field Evaluation. Three hundred and seventy four tubers of cvs. Russet Burbank, Russet Norkotah, Red Pontiac, and Shepody were tested in the lab using duplex PCR and then planted in the field for symptom observation. Leaves from these plants were tested using ELISA and in some cases duplex PCR for comparisons of tuber test in the laboratory.

Results and Discussion

The original duplex PCR reported for detection for PVY and PLRV in aphids (Singh *et al.*, 1996) did not work with RNA extracted from dormant tubers of cvs. Shepody, Russet Burbank and Russet Norkotah. However, when primers were tested individually (simplex PCR) most of the tubers were found positive for PVY and PLRV. Similar observations were also reported by Coffin *et al.* (1997) and Russo *et al.* (1998). Therefore, several experiments as outlined in the materials and methods section were performed to develop a duplex PCR system for detection of PVY and PLRV from dormant tubers.

Effect of dNTP's Changes During RT and PCR Stage. In routine simplex RT-PCR, 0.5mM of each dNTP's is used at RT level and 0.2mM during PCR (Singh, 1998). However, when duplex RT-PCR was performed at o.5mM dNTP's concentration, the amplified products were not always clearly visible. Increasing the amount of each dNTP's up to 1.5mM during RT stage, improved the detection of both PLRV and PVY, but did not have any effect on simplex PCR either with PLRV or PVY.

Similar observations a recorded in duplex PCR were obtained with multiplex PCR also at RT stage. PVY, PLRV, and PVS bands were more intense at 1.0 or 1.5mM concentration in comparison to 0.5mM.

To determine whether a similar effect can by obtained by the increased dNTP's concentrations applied during the PCR stage, four concentrations (0.1, 0.2, 0.5, and 1.0mM) in duplex PCR; 0,2 and 0.5mM in multiplex PCR were tested at PCR stage. The cDNA used in these evaluations has 0.5mM dNTP's and optimized primer ratio. There was no visible improvement due to the increased dNTP's concentration used during the PCR stage for either duplex or multiplex PCR's. However, good amplification of single virus band was observed in simplex PCR. Amplification in all (simple, duplex, and multiplex) PCR's was inhibited at increased concentrations of dNTP's.

Bariana *et al.* (1994) have used a high concentration of 1.5mM during RT and only about half the amount during PCR for the detection of five seedborne legume viruses in a multiplex PCR. These authors state that the conditions for multiplex PCR were arrived after extensive evaluation, which supports present finding.

Effect of Antisense Primer Ratio at RT Stage. The higher concentration (1.0mM) of primer is shown to produce artifacts, where as lower concentrations (0.5mM) amplified all bands similarly in a multiplex PCR (Chamberlain and Chamberlain, 1994). Therefore to determine the ration of PLRV:PVY antisense primers is duplex and oligo dT: PLRV in multiplex was tested at different concentration.

In duplex PCR, both PLRV and PVY antisense primers were tested at six combinations. PLRV antisense combinations were: 0.28, 0.41, 0.70, 0.83, 0.90, and 0.97uM, while PVY antisense primers were: 1.1, 0.97, 0.70, 0.56, 0.44, and 0.41uM. The optimal yield of both bands were observed at the PLRV:PVY primer ratio of 0.90:0.49uM.

In multiplex PCR, oligo dT mixture was tested at 0.40 and 1.0uM concentration in combination of 0.65uM of PLRV antisense primer. The best amplification was obtained at a primer ratio of oligo dT:PLRV of 1.0:0.65uM. This could be due to the fact that oligo dT is used as an universal primer for cDNA synthesis of PVY and PVS, since both of these viruses have common 3' poly-A tail. Therefore, in order to synthesis cDNA from both viruses, more primer is needed.

Effect of RNA Template Concentration in RT. In simplex PCR, DNA dilutions of 1:20 or lower have been used during RT (Singh, 1998). To determine the optimum template concentration with optimized antisense primer ratio, RNA template dilutions of 1:20, 1:100, 1:200, and 1:300 were tested. When RT was carried at 0.5mM dNTP's, distinct bands of both viruses were visible at 1:20 dilution and not at any other dilutions. This indicated that lack of dNTP's could be overcome by using excess template concentration. However, an increase of dNTP's to 1.0mM in RT produced distinct bands in all four dilutions which improved sensitivity by 15-fold. It is possible that an increase in dNTP's concentration at RT level improved the quality and quantity of cDNA synthesized.

Effect of Optimized RT Conditions on the Composite Sample Detection. Composite samples consisting of one part of infected sap to various parts of healthy sap were mixed, nucleic acid extracts were prepared from the mixture and used for detection of PLRV and PVY by duplex RT-PCR. Both viruses were clearly detected up to a dilution or 1:400 and both viruses were observed faintly on the gel up to a dilution of 1:1000.

Effect of Various Factors During PCR. The reaction mix from optimized RT was subjected to standardized PCR using dilutions of composite samples. These dilutions were evaluated in three separate tests by varying three factors: 1) a four-fold increased amount of amplitaq to 2.5U; 2) an annealing temperature of 60°C instead of 57°C as used in the standard PCR; and 3) an increased polymerase extension time of 2 min per PCR cycle. Remaining conditions for PCR were the same as the standardized PCR. The bands of both viruses were slightly more intense when the amount of enzyme was increased or when the extension time was increased to 2 min. However, there was essentially no noticeable difference in the band intensity with increased annealing temperature.

In multiplex PCR, two different primer combinations (oligo dT 0.7um, PVY sense primer 1.0uM, carla uni 0.4uM, PLRV antisense and sense 0.4uM each; oligo dT 1.0uM, PVY sense primer 0.625uM, carla uni 0.4uM, PLRV antisense and sense

0.375uM each) were tested with two combinations of antisense primers (oligo dT 1.0uM, PLRV antisense 0.65uM; oligo dT 0.40uM, PLRV antisense 0.65uM). As described previously, at the optimized antisense primer ratio (oligo dT 1.0uM and PLRV antisense 0.65uM), the best amplification was obtained with primer ratio fo oligo dT 1.0uM, PVY sense 1.0uM, carla uni 0.4uM and PLRV antisense and sense 0.4uM.

Application of Optimized Duplex RT-PCR to Field-grown Tubers. The optimized set of conditions finally included in the duplex RT-PCR consisted of dNTP's concentration of 1.0mM and the PLRV:PVY antisense primer ratio of 0.90:0.49uM during the RT step and the polymerase extension time of 2 min. instead of 1 min during PCR.

One hundred and ninety tubers from a heavily PLRV infected and a similar number of tubers from a lightly infected lot of Russet Burbank were tested using duplex RT-PCR. Similarly, fifty two tubers of Shepody, 97 tubers of Red Pontiac, 145 tubers of Russet Norkotah, and 76 tubers of Russet Burbank from field belonging to different lots were also tested.

From the heavily infected lot of Russet Burbank with natural infection of PLRV and PVY, 158 showed PLRV alone, 21 PLRV + PVY, and 8 PVY alone. As expected from lightly infected lot, 16 showed PLRV alone, 1 PLRV + PVY, and 5 PVY alone.

In cvs. Shepody out of 52 tubers, 4 showed PLRV alone, 3 PLRV + PVY, and 4 PVY alone; out of 97 tubers of Red Pontiac, 54 showed PVY and no PLRV; out of 145 Russet Norkotah, 75 showed PLRV alone, 4 PLRV + PVY, and 9 PVY; out of 76 Russet Burbank, 3 showed PLRV alone, 5 PLRV + PVY, and 46 PVY alone (Table 2).

Comparison of Plant Symptoms and Detection by Duplex RT-PCR in the Greenhouse. One seed piece from each tuber heavily infected samples of Russet Burbank were planted in the greenhouse for observation of symptoms over a three month period. Of the 190 plants, visual assessment estimated 154 plants exhibiting leafroll symptoms. In support of these data PLRV was detected from the leaves by duplex RT-PCR in 152 plants and two plants contained both PLRV and PVY (Table 1). In visual observations of the remaining plants, 20 showed a mixture of lefroll and mosaic, 9 mosaic alone and 7 appeared symptomless (Table 1). Verification of these data by duplex RT-PCR revealed that of the 20 plants sharing a combination of leafroll and mosaic symptoms, 19 contained both PLRV + PVY, while one plant was healthy. Of the 9 plants exhibiting mosaic, 8 plants were PVY infected and one was healthy. Of the 7 plants that appeared symptomless, 4 contained PLRV alone, indicating masking of leafroll symptoms, and three were healthy. A nearly perfect correlation ($r^2 = 0.99$) was observed (Table 1). Upon re-examination of the original tubers of these three plants,

Table 1. Comparison of virus symptom expression and duplex RT-PCR detection of PLRV and PVY in tubers and leaves in the greenhouse

		Duplex RT-PCR detection						
		Tubers			Leaves			
Plant symptoms	No of Plants	PLRV	PVY	PLRV+PVY	PLRV	PVY	PLRV+PVY	Healthy
Leafroll	154	154	0	0	152	0	2	0
Leafroll, mosaic	20	0	0	20	0	0	19	1
Mosaic	9	0	9	1	0	8	0	1
Symptomless	7	6	0	0	4	0	0	3
Total	190[a]	160	9	21	156	8	21	5

[a] Correlation coefficient (r^2): (1) 0.99 between plant symptoms and leaf tests based on the 4 pairs of input data, i.e., 154-152, 20-19, 9-8, and 7-3; (2) 0.99 between plant symptoms and tuber tests based on 4 pairs of input data, i.e., 154-154, 20-20, 9-10, and 7-1; (3) 0.99 between leaf tests and tuber tests based on 12 pairs of input data: 154-154, 0-0, 0-2, 0-0, 0-0, 20-19, 0-0, 9-8, 1-0, 6-4, 0-0, and 0-0.

absence of PLRV was confirmed. Thus the earlier duplex RT-PCR performed on tubers falsely identified two of these as positive for PLRV.

Comparison of Plant Symptoms and Detection by Duplex RT-PCR in the Field. Whole tubers of cvs. Shepody, Red Pontiac, Russet Norkotah, and Russet Burbank were planted in the field on June 1,1999. These tubers were tested in the lab with duplex PCR in late March. Most of these tubers had natural dormancy break. Of the 52 Shepody tubers, 50 exhibited PVY symptom alone and 2 in combination of both PLRV + PVY, where as leaf ELISA detected 48 PVY alone and 4 in combination (Table 2). In support of these data duplex RT-PCR detected 30 PVY alone, 4 PLRV alone, and 3 PLRV + PVY (Table 2).

Of the 97 Red Pontiac tubers, 89 exhibited visual PVY symptoms and 88 detected by leaf ELISA. No PLRV was observed by either of the tests. In support of these data, duplex RT-PCR detected 54 PVY and no PLRV (Table 2).

Of the 145 Russet Norkotah tubers, 54 exhibited visual PVY symptoms alone, 37 PLRV alone, and 41 in combination of PLRV + PVY. However, ELISA detected 65 PVY, 27 PLRV, and 43 PLRV + PVY. In support of these data, duplex RT-PCR detected 9 PVY alone, 75 PLRV alone, and 4 PLRV + PVY (Table 2).

Out of 76 Russet Burbank tubers, visual examination revealed 72 PVY, 1 PLRV, and 1 PLRV + PVY. However, ELISA detected 67 PVY and 2 PLRV and 7 PLRV + PVY. In support of these data, duplex RT-PCR detected 46 PVY alone, 3 PLRV alone, and 5 PLRV + PVY (Table 2).

Table 2. Comparison of virus symptom expression and duplex RT-PCR detection of PLRV and PVY in tubers and comparison with ELISA on the leaves and visual symptoms in the field

		TUBER PCR			LEAF ELISA			VISUAL		
Variety	**# of tubers**	**PVY**	**PLRV**	**Y+LR**	**PVY**	**PLRV**	**Y+LR**	**PVY**	**PLRV**	**Y+LR**
SHEPODY	52	30	4	3	48	0	4	50	0	2
RUSSET BURBANK	76	46	3	5	67	2	7	72	1	1
RED PONTIAC	97	54	0	0	88	0	0	89	0	0
RUSSET NORKOT	145	9	75	4	65	27	43	54	37	41

Conclusions

The duplex RT-PCR method for the simultaneous detection of PLRV and PVY in aphids did not work with dormant tubers. This study demonstrates that the optimization of dNTP's concentration, the antisense primer ratio of viruses, and the RNA template concentration at the reverse transcription stage improves detection by RT-PCR of both viruses in tubers and leaves. In greenhouse test a perfect correlation between RT-PCR on tuber and leaves along with visual symptoms was found. However, in field evaluation, duplex RT-PCR under-estimated both viruses in all four varieties. One possible explanation for this discrepancy between greenhouse and field evaluation might be that tubers evaluated in the greenhouse were tested at the dormant stage, where as field evaluated tubers were tested in late March, with some sprouts, however, sprouts were not included in the RNA extraction. Therefore, it needs further evaluation in the field.

Multiplex RT-PCR evaluated for the detection of PVY, PLRV, PVS, and PVM is being used in our laboratory for testing plantlets coming out from virus eradication program. However, it's use for testing dormant tubers would need extensive laboratory and field evaluation.

Acknowledgments

I would like to acknowledge the help and support of Dr. Rudra P. Singh, AAFC, Fredericton, for collaboration in this project. Also, Dr. Loretta Mikitzel and Mr. Robert Gareau for editing the manuscript; Angela Gallagher and Samantha Ford for technical assistance; NB Department of Agriculture and Rural Development for funding under project no. ARP 97050-2.

References

Badge, J., Brunt, A., Carson, R., Dagless, E., Karamagiolo, M., Phillips, S., Seal, S., Turner, R., and G.D. Foster, 1996. A carlavirus - species PCR primer and partial nucleotide sequence provides further evidence for the recognition of cowpea mild mottle virus as a whitefly - transmitted carlaviurs. *European Journal of Plant Pathology* **102**: 305 - 310.

Bariana, H.S., Shannon, A.L., Chu, W.G., P. Waterhouse, 1994. Detection of five seed borne legume viruses in one sensitive multiplex polymerase chain reaction test. *Phytopathology* **84**: 1201 - 1205.

Beemster, A.B.R., A. Rozendaal, 1972. Potato viruses: properties and symptoms. In: J.A. de Bokx (td.), Viruses of Potatoes and Seed Potato Production. Pudoc, Wageningen, pp. 115 - 143.

Chamberlain, J.S. and J.R. Chamberlain, 1994. Optimization of multiplex PCRs. In: Mullis K.B., Ferre, F., Gibbs, R.A. (Edsl), The Polymerase Chain Reaction. Birkhauser, Boston, pp. 38 - 46.

Coffin, A., Sturz, A.V. and R.P. Singh, 1997. Evaluation fo a RT-PCR method for the simultaneous detection of PLRV and PVY^o in field grown tubers. *American Potato Journal* **74:** 423.

Pappu, S.S., Brand, R., Pappu, H.R., Rybicki, E.P., Gough, K.H., Frenkel, M. and C.L. Niblett, 1993. A polymerase chain reaction method adapted for selected amplification and cloning of 3' sequences of potyviral genomes: application to Dasheen mosaic virus. *Journal of Virological Methods* **41:** 9 – 20.

Russo, P., Miller, L., Singh, R.P. and S.A. Slack, 1999. Comparison of Florida winter test with PCR assay for PVY and PLRV in dormant tubers. *American Potato Journal* **75:** 296.

Singh, M. and R.P. Singh, 1995. Digoxigenin - labeled cDNA probes for thedetection of potato virus Y in dormant potato tubers. *Journal of Virological Methods* **52:** 133 - 143.

Singh, M. and R.P. Singh, 1996. Factors affecting detection of PVY in dormant tubers by reverse transcription polymerase chain reaction and nucleic acid spot hybridization. *Journal of Virological Methods* **60:** 47 - 57.

Singh, R.P., 1998. Reverse transcription polymerase chain reaction for the detection of viruses from plants and aphids. *Journal of Virological Methods* **74:** 125 - 138.

Singh, R.P., Kurz, J. and G. Boiteau, 1996. Detection of stylo borne and circulative potato viruses in aphids by duplex reverse transcription polymerase chain reaction. *Jounal of Virological Methods* **59:** 189 - 196.

Singh, R.P., Kurz, J., Boiteau, G. and G. Bernard, 1995. Detection of potato leafroll virus in single aphids by the reverse transcription polymerase reaction and its potential epidemiological application. *Journal of Virological Methods* **55:** 133 – 143.

SMALL FRUIT / PETITS FRUITS

DEVELOPMENT OF AN ENVIRONMENTAL MANAGEMENT STRATEGY FOR THE CONSERVATION AND ENHANCEMENT OF INDIGENOUS BEES WITHIN THE NEW BRUNSWICK WILD BLUEBERRY AGRO-ECOSYSTEM

ELABORATION D'UNE STRATEGIE DE GESTION DE L'ENVIRONNEMENT POUR PRESERVER ET AMELIORER L'ETAT DES ABEILLES INDIGENES DANS L'AGROECOSYSTEME DES BLEUETS SAUVAGES AU NOUVEAU-BRUNSWICK

Steven K. Javorek[1]

Partner/Partenaire: New Brunswick Wild Blueberry Growers Association / Association des producteurs de bleuets sauvages du Nouveau-Brunswick

Abstract: The spatio-temporal patterns of habitat utilization by indigenous bees within the New Brunswick wild blueberry agro-ecosystem were studied in 1998 and 1999. *Andrena* nesting was generally restricted to commercial blueberry fields while *Bombus* established nests in undisturbed woodlands, open thickets and old field habitats. The *Vaccinium angustifolium* flowering period overlaps with only 37-41% of the entire life span of *Andrena*, 27-34% of the *Bombus* queen foraging phase and just 5-18 days of the *Bombus* worker activity period. As such, alternative forage is required to maintain indigenous bee populations for blueberry pollination. A total of 50 plant species were identified as primary bee forage over the April to September study period. When flowering plant populations were separated into habitat specific categories it was apparent that floral availability was unevenly distributed, both spatially and temporally, throughout the study areas. These habitat-linked floral assemblages resulted in not only the need for bee populations to exploit a changing array of forage plants, but to switch between several habitats over the course of individual or colonial life spans. The availability of primary forage yielding habitats (forest edges, open thickets, commercial blueberry fields and wild flower areas) affected bee abundance within study areas.

Résumé : Les modes spatiotemporels d'utilisation de l'habitat par les abeilles indigènes ont fait l'objet d'une étude en 1998 et 1999 dans quatre agroécosystèmes des bleuets sauvages au Nouveau-Brunswick. La nidification des andrènes (*Andrena*) se limite généralement aux bleuetières commerciales, tandis que les bourdons (*Bombus*) nidifient dans les boisés intacts, les taillis ouverts et les anciens champs. La période de floraison du bleuet nain (*Vaccinium angustifolium*) chevauche seulement 37 à 41 % de la durée de vie totale des andrènes, 27 à 34 % de la période de butinage de la reine des bourdons, et seulement 5 à 18 jours de la période d'activité des ouvrières de l'espèce *Bombus*. Il faut donc compter sur un fourrage de remplacement pour retenir les populations d'abeilles indigènes pour la pollinisation des bleuets. Pendant l'étude échelonnée d'avril à septembre, on a dénombré un total de 50 espèces végétales que les abeilles peuvent utiliser comme source d'alimentation principale. Après avoir classé les populations de plantes à fleurs par catégorie d'habitat, nous avons observé que la disponibilité des fleurs n'était pas bien répartie, tant spatialement que temporalement, dans toutes les zones à l'étude. Les assemblages floraux liés à l'habitat obligent les populations d'abeilles non seulement à exploiter différentes stations florifères, mais aussi à changer plusieurs fois d'habitat pendant leur vie individuelle ou en colonie. La disponibilité d'habitats primaires favorables au butinage (bordure des forêts, taillis ouverts, bleuetières commerciales et stations de fleurs sauvages) a modifié l'abondance des abeilles dans les zones à l'étude.

Introduction

A diverse pollinator guild, whose membership includes both introduced and indigenous species, services the pollination requirements of the commercial wild

---

[1] Diversified Pollination Systems, P.O. Box 633, Kentville, NS B4N 3X7

blueberry crop (*Vaccinium angustifolium*) in New Brunswick. Recent improvements in crop management practices have dramatically increased crop potential, leading to, and correctly so, an increased awareness of the essential role played by introduced bees (honey bees) in achieving maximum yields. Although this thinking is correct, it often leads to the interpretation of achieved pollination levels based solely on the introduced component of the pollinator fauna. The pollination contribution of indigenous bees and the intrinsic benefits of bee diversity must not become lost in the pollination shuffle.

As individuals, the pollination effectiveness of many indigenous bees is far superior to their introduced counterparts. The pollination success rates (the percentage of floral visits resulting in successful pollination events) of the members of the indigenous genera *Andrena* spp., *Bombus* spp. and *Halictus* spp., when considered as a group, is almost four times that of honey bees (88.3% for the former and 23.8 for the latter)(Javorek and Vander Kloet, 1999). This same group of indigenous pollinators deposited almost three time the number of pollen tetrads per single visit (38 tetrads) than honey bees (12.9 tetrads). The quality of a floral visit (i.e. the number of tetrads transferred to the receptive stigma) has a strong bearing on whether a fruit will develop and the eventual size of a fruit produced. The presence of male and female sterility in *V. angustifolium*, as well as many clones producing poor pollen quality tend to diminish seed set per berry (Vander Kloet, 1983). Therefore, increased pollination efficacy associated with indigenous pollinators leads to higher seed set and, by extension, larger berry size and higher yield.

The important pollination contribution of indigenous bees was nowhere more evident than in southern New Brunswick when crop yield dropped significantly as a result of the decimation of bee populations caused by fenitrothion spraying for spruce bud worm control from 1969 to 1973 (Kevan, 1978). Although population recovery was evident following the cessation of the spray program, the sheer magnitude of the affected area (1000 + square acres) lead to a rate of recovery that was considerably slower (seven-plus years) than the predicted rate (1 - 4 years). Furthermore, it is unclear whether the final resident populations of these re-colonized areas are the same as the original and what, if any, effect this may have on current pollination.

The composition of the indigenous pollinator guild appears to be different between the southern and northern growing regions (MacKenzie et al., unpublish. data). In the south, *Andrena* spp. *Bombus* spp. and members of the Halictidae are well represented, with each taxa taking its turn as the most abundant pollinator depending on the site/year. In contrast, the pollinator force in the northern region has a similar relative density of *Andrena* spp. but is dominated by Halictids with *Bombus* spp. abundance much lower. Despite the fact that populations of indigenous bees rarely reach the foraging densities required to achieve maximal pollination, their contribution is substantial. In the south, where the introduction of managed bees is more prevalent, indigenous bees average 55% of the total pollination force with foraging densities ranging from 0.4 - 2.1 bees/m^2. In the northern growing regions indigenous bees comprise an average of 89% of the pollination force with foraging densities ranging from 0.3 - 2.4 bees/m^2.

Bee abundance depends on a number of factors, any of which may be a limiting factor. These main factors are (1) fluctuations in yearly climatic conditions, (2) availability of suitable nesting sites and (3) the availability of suitable forage throughout the life span of a bee (Edwards, 1996). Climatic variation is unpredictable, and as such, little if anything can be done to moderate its effects as a limiting factor on bee population. This is not the case for nesting and foraging areas. A habitat management plan that encompasses the provision of increased nesting habitat and adequate forage availability can reduce the limiting effects of both these factors in the wild blueberry agro-ecosystem thus enhancing pollinator abundance.

The overall objective of this study was to investigate how the major pollinator taxa (*Andrena* and *Bombus*) spatially and temporally utilize the landscape mosaic so guidelines can be established to manage habitat in blueberry growing areas for the conservation and enhancement of pollinator populations. This was accomplished by:

(1) Establishing the seasonal phenology, nesting microenvironments and foraging fight ranges of *Andrena* and *Bombus*.
(2) Determining the spatio-temporal abundance and distribution of flowering plants within wild blueberry agro-ecosystems.
(3) Determining the spatio-temporal abundance and distribution of bees within wild blueberry agro-ecosystems.
(4) Establishing the taxonomic patterns floral and habitat utilization of indigenous pollinators.

Materials and Methods

Study Sites and Habitat Descriptions. A total of eight study sites were used during this study (Figure 1). The primary study sites used in 1999 to investigate the spatio-temporal patterns of habitat utilization by indigenous bees were: (1) Jonah Mountain, Albert County (45°52'N, 64°50'W), (2) Harrison Settlement, Albert County (45°53'N, 65°01'W), (3) Val Doucet, Gloucester County (47°35'N, 65°17'W) and (4) Pokemouche Landing (growing area known locally as Lord and Foy), Gloucester County (47°31'N, 65°14'W). At each of these sites, a 2×3 kilometre study area was delineated. The type and relative percentage of habitats within each study area was established using field mapping, aerial photographs and topographic maps.

In addition to these primary sites, floral and bee abundance was monitored in 1998 and 1999 at Gowland Mountain, Albert County (45°49'N, 65°02'W) and

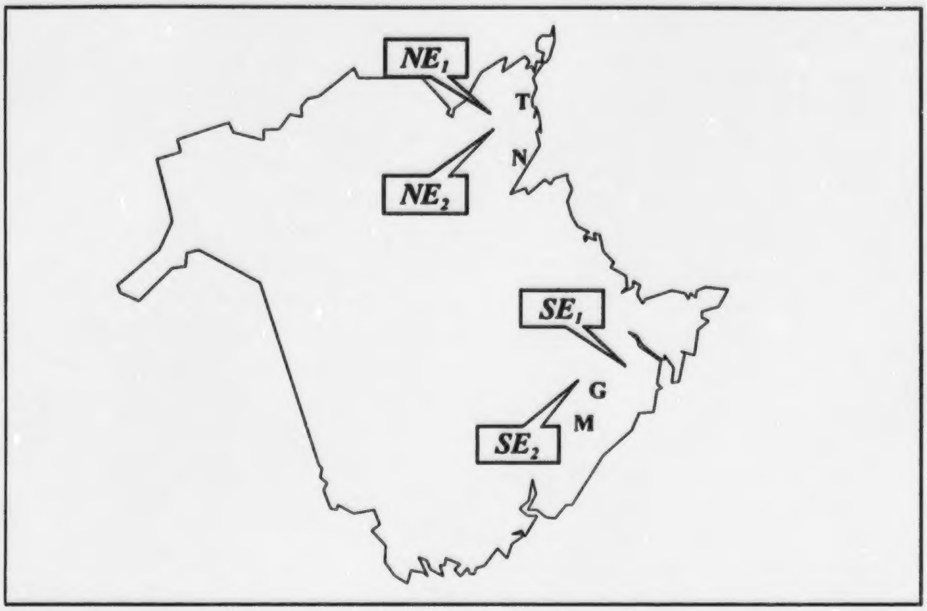


Fig. 1. Study Sites. Primary study areas: SE_1 (Jonah Mountain), SE_2 (Harrison Settlement), NE_1 (Val Doucet), NE_2 (Pokemouche Landing). Secondary study areas: M (Mechanic Settlement), G (Gowland Mountain), N (Neguac), T (Tracadie).

Mechanic Settlement, Kings County (45°44'N, 65°15'W) in the Southeast and at Neguac, Northumberland County (47°18'N, 65°05'W) and Tracadie, Gloucester County (47°33N, 64°56W) in the Northeast.

Bee Phenology. Bee collections from each study site were made every 7-12 days starting in April with the commencement of seasonal bee activity and ran through until the first of September. At each site, bees were collected from two 1×20 metre transects within each habitat present. These collections were supplemented with bees taken from nesting or non-resource sites. Specimens were pinned and sorted by date and species. For *Andrena*, the dates of initial and final presence in samples indicated the population life span of a particular species. Similarly, for *Bombus*, the samples showed the duration of each stage of the colony cycle (queens → workers → reproductives). Phenologies were used to establish the temporal foraging requirements of different taxa within the wild blueberry agro-ecosystem.

Nest Distribution and Micro-Environment. Commencing in early April (1998/1999), study areas were traversed biweekly using a "search and find" method to locate *Andrena* and *Bombus* nesting sites. For each *Andrena* nest encountered the following information was recorded: (1) species (voucher specimens were collected to aid in identification), (2) general habitat, (3) date of nest establishment and (4) ground cover. For selected *Andrena* species, marked nests were excavated at the end of the blueberry flowering period to determine (1) nest architecture (depth), (2) natal cell production and (3) soil type. For *Bombus*, the (1) species, (2) general habitat, and (3) nest description (i.e. abandoned mouse tunnel, fallen log) were recorded for all nests encountered.

Foraging Flight Range. To establish foraging range in relation to resource availability, two nesting sites for each of four *Andrena* species were demarcated within the Jonah Mountain agro-ecosystem. For each species, one nesting area was in/adjacent to the crop portion of the blueberry field with the other in/adjacent to the sprout portion (minimum of 900 metres from the bearing field). The four *Andrena* species investigated ranged in size: *A. carlini*: 14mm, *A. regularis*: 11mm, *A*. sp.1: 10mm and A. *alleghaniensis*: 9mm.

Emergence phenology for each of the nesting sites was monitored. Starting with the commencement of nest initiation until the cessation of nesting activity, 25 female bees from each of the nest areas were marked weekly using a Liquid Paper® all purpose correction pen (n=200 bees/nest site). All bees were marked on the dorsal thorax. Bees residing in the crop portion of the field were assigned a dot (•) and those in the sprout portion a vertical line (|). During weekly floral surveys (see below for methodology) the location of marked individuals was recorded. Straight-line distances were calculated from the position where the bee was observed (recapture site) to the nesting area where it was marked (mark site). The foraging flight ranges in relation to each nesting site were determined for each species. Ranges were compared between those bees nesting in/adjacent the crop portion of the field and those nesting in/adjacent the sprout portion of the field. In addition, nests were excavated at each nesting site to compare natal cell production in relation to floral availability.

Spatio-Temporal Abundance and Distribution of Flowering Plants. At each study site, four, 1×20 metre transects were delineated within each habitat in early April, prior to the onset of flowering and bee activity. Monitoring was conducted every 7-12 days until early September. On each census date, the floral density and composition within each identified habitat was determined by counting the number of open flowers of each species present within transects. These data were compiled following the end of seasonal monitoring to construct (1) bloom phenology of individual plant species and (2) spatial and temporal changes of floral availability within the entire study area.

In order to determine the amount of floral resources available within each 2×3 kilometre study area (known hereafter as site-wide floral volume), the following formula was used:

$$\text{S-W Floral Volume} = (\text{FLD}_1 \times \%\text{H}_1) + (\text{FLD}_2 \times \%\text{H}_2) + \ldots + (\text{FLD}_n \times \%\text{H}_n)$$

where; FLD = Floral Density and %H = relative percentage of the study area covered by the habitat. This eliminates the bias imposed by variable sized habitats within a given study area. For example, a relatively small habitat with a high floral density would lead to an overestimation of floral availability at a particular site if respective floral densities from each incumbent habitat were simply added together. Therefore, it is necessary to incorporate the relative percentages occupied by each habitat along with measures of floral density to accurately show floral volume within a study site. This not only allows the calculation of floral volumes within a given study areas but enables site-wide floral volumes to be compared directly among study sites.

Spatio-Temporal Abundance and Distribution of Bees. At each study site, bees were censused between 10:30 am and 3:30 pm. The same 1×20 metre transects used to establish floral abundance were monitored on corresponding census dates for 5 minute periods to ascertain bee abundance. This provided a total of 300 minutes of observational data per habitat at each site over the study period. For each transect the observer recorded all bees according to taxon and floral host. To eliminate possible diurnal patterns of floral utilization, two plots from each habitat were censused in the morning and two in the afternoon. To minimize environmental effects on bee activity, only warm, sunny/partly sunny days in the 7-12 day monitoring window were used as census dates. To aid in the further identification of the foraging guild, a fifth transect in each habitat was sampled destructively for a five minute period. Bees were captured using a net then euthinized with ethyl acetate in a killing jar. Each killing jar was labelled with the appropriate habitat and plant species from which the bee was taken. All bees obtained during this study were pinned, labelled and sorted by date, bee species, habitat and floral host. Both non-destructive and destructive samples were used to determine spatio-temporal and taxonomic patterns of habitat/floral utilization.

In order to determine bee abundance over entire 2×3 kilometre study areas (known hereafter as site-wide bee volume), the following formula was applied:

$$\text{S-W Bee Volume} = (FD_1 \times \%H_1) + (FD_2 \times \%H_2) + \ldots + (FD_n \times \%H_n)$$

where, FD = Foraging Density and %H = relative percentage of habitat covered by habitat. As with the calculation of site-wide floral volume, this eliminates bias from variably sized habitats within a study area, ultimately reducing over or underestimation of bee populations that would arise from simply tallying respective foraging densities from each habitat within a given study area. As well, site-wide bee volumes can be directly compared among study sites.

Taxonomic Patterns of Habitat Utilization. On each census date, the percentage of total site-wide floral availability was determined for each habitat. Similarly, the percentage of taxa-specific bee abundance was established for each habitat. If bees do not discriminate among forage yielding habitats, the relative percentage of a given bee taxa should be proportional to the relative percentage of forage within each habitat. Chi-square analysis was used to test observed foraging percentages against expected values.

Taxonomic Patterns of Floral Utilization. Pollen loads were removed from *Andrena* and *Bombus* workers returning to nesting sites on each census date. For *Andrena*, bees were captured at nest entrances. Because of the difficulty locating *Bombus* nests, pollen loads were taken from *Bombus* (queens and workers) moving through the woodland habitat. The assumption being that since the woodland was, for the most part, a non-foraging habitat, that *Bombus* captured here with pollen loads were either (1) returning to nesting sites or (2) moving between foraging areas. This removed bias associated with capturing bees on a particular floral host. Each pollen load was placed in a vial and labelled with taxa and date. Pollen loads were subsequently mounted in silicon gel on microscope slides and observed at 400X. To aid in the classification, reference pollen samples were collected from the most abundant flowering plants on each census date. Pollen analysis was used to establish the primary floral hosts for *Andrena* and *Bombus* during pre-*Vaccinium*, *Vaccinium* bloom and post-*Vaccinium* periods.

Analysis. All floral densities reported in the paper, unless otherwise stated, will refer to density / 1×20 metres. Similarly, all bee density will be reported as bees / 1×20 metres / 5 minutes. Statistical summaries are given as mean ± standard deviation unless otherwise noted.

Results

Study Sites and Habitat Descriptions. A total of seven distinct habitats were identified within wild blueberry agro-ecosystems investigated during this study. The type and relative percentage of habitats present within each 2 × 3 kilometre study area is listed in Table 1. Commercial blueberry fields were classified as either crop or sprout fields. The ecotone between blueberry fields, clear-cuts, open thickets, access roads and the Woodland was considered Forest Edge habitat. The term Clear-cut in this study refers to those areas that have just recently undergone logging (2 years) and have yet to develop strong assemblages of flowering plants. Areas such as this that had advanced to early successional stages, characterised by abundant flowering plants were termed Open Thickets. Floral enclaves within blueberry fields, along roadways or old fields were classified as Wild Flower areas. All forested areas within the study areas were considered Woodland habitat.

Bee Phenology. The relationship of any bee taxa with its surrounding ecosystem must first be placed in context by establishing the time frame of the interaction. The seasonal phenologies of *Andrena* and *Bombus* (queens and workers) from Southeastern and Northeastern New Brunswick are shown in Figure 2. *Andrena* and *Bombus* queens appeared from mid April to early May, 17 to 31

Table 1. The percentage of each 2×3 kilometre study area covered by specific habitats.

Habitat	% Study Area Covered by Habitat			
	SE_1	SE_2	NE_1	NE_2
Blueberry (Crop)	16	10	19	25
Blueberry (Sprout)	16	10	21	28
Forest Edge	5	3	5	3
Wild Flower	7	3	4	NP
Open Thicket	8	10	5	NP
Clear Cut	6	NP	NP	NP
Woodland	42	64	46	44

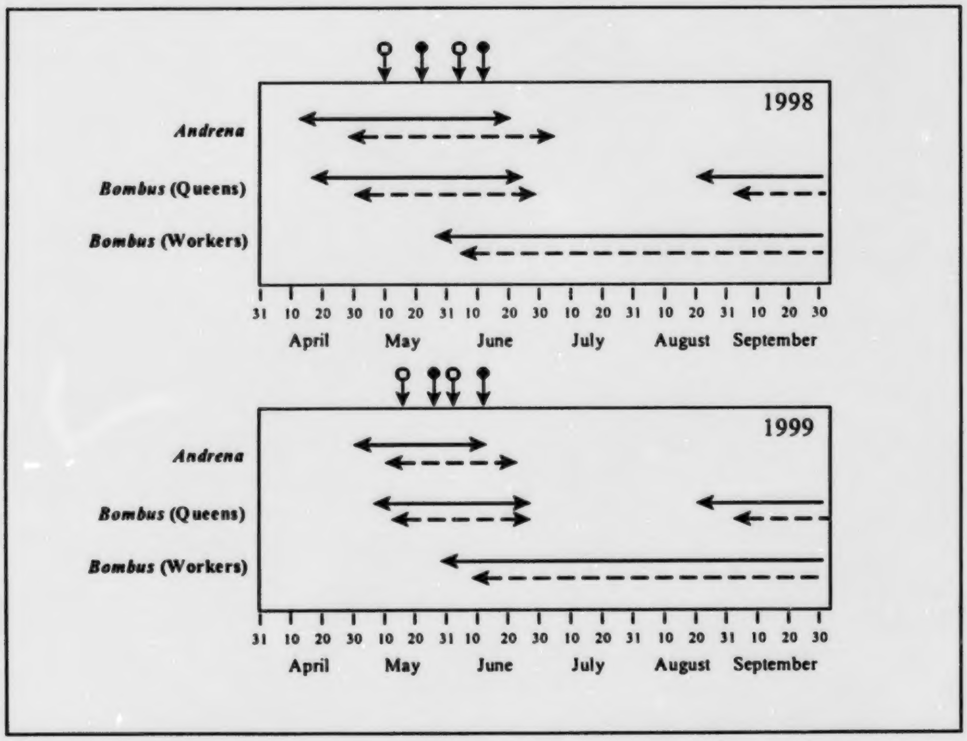


Fig. 2. *Andrena* and *Bombus* (queens, workers and reproductives) seasonal phenologies from Southeastern (solid lines) and Northeastern (dashed lines) New Brunswick in 1998 and 1999. Vertical arrows at the top of charts indicate the duration of the *Vaccinium* flowering period (open circles: SE, solid circles: NE).

days in advance of the blueberry flowering period (depending on the year and geographic region). These bees were often active before all the snow had melted. When considered as a group, *Andrena* population life span ranged from 51 to 69 days (mean: 59 days). The foraging period for *Bombus* queens (*B. ternarius*, *B. terricola*, *B. vagans*, *B. impatiens*, and *B. perplexus*) lasted 69 to 82 days (mean: 75 days). B*ombus* workers first appear during mid blueberry bloom (late May to early June) and remained active until fall. By mid summer *Bombus* males and new queens were present. Both workers and reproductives were active into September.

For *Andrena*, the pre-*Vaccinium* period ranged from 17 to 31 days and averaging 39% of the life span. The *V. angustifolium* flowering period ranged from 21-28 days and occupied from 37 to 41% of the *Andrena* population life span. For *Bombus*, the pre-*Vaccinium* flowering period lasted 17 to 26 days and occupied an average of 30% of the queen foraging period and just over 13% of the entire colony cycle. The *Vaccinium* flowering period occupied an average of 32 % (range: 27to 34%) queen foraging period and approximately 15% of the colony cycle. *Bombus* workers foraged on blueberry anywhere from 5 to 18 days.

Nest Distribution and Micro-Environment. All of the *Andrena* nests (1998: n=214, 1999: n=347) identified in this study were restricted to the blueberry field (crop and sprout portions) and dirt roadways that traversed the study areas. Higher *Andrena* abundance at the SE study sites resulted in the location of more nests (1998: n=176, 1999: n=291) than at the NE sites (1998: n=38, 1999: n=56). The nests of seven species (*A. carlini*, *A. vicina*, *A. regularis*, *A. alleganiensis*, *A. crataegi*, *A.* sp.1, *A.* sp.2) were identified from the SE sites. In the NE, only the nest sites of *A. carlini*, *A. vicina*, and *A. regularis* were located.

The majority of *A. carlini* nesting tunnels were located in areas of nil to sparse plant cover along dirt roadways within or leading to blueberry fields. All nests entrances were unobscured by vegetation. This species nested non-aggregately, however, the limited nesting micro-environment did occasionally result in several nests being established in close proximity to one another. At southern sites, average tunnel depth was 17.1 ± 2.1 (range: 14-23cm, n=8) and contained an average of 6.7 ± 0.8 natal cells. At northern sites, mean tunnel depth was significantly shallower than at southern sites ($t=2.49$, $p<0.05$). Average tunnel depth at the northern sites was 13.6 ± 3.4 cm (range: 8-19cm, n=8) and contained 4.6 ± .07 natal cells.

Both *A. regularis* and *A. vicina* nested aggregately in areas of sparse stem density within the blueberry field. When found concurrently at study sites, tunnel densities were similar for both these species. Tunnel density *for A. regularis* and *A. vicina* at southern sites averaged 21.5 ± 6.3 / m^2 (n= 8 aggregations) and 19.7 ± 5.4 / m^2 (n=6 aggregations), respectively. Here, nest depths for *A. regularis* ranged from 14 to 21cm (mean: 17.3 ± 2.3cm, n= 8) with an average of 4.1 ± 1.1 (range: 2-6, n= 8) cells per tunnel. *A. vicina* tunnels were not excavated. At SE_1

and SE_2, nest aggregations of both species were located sporadically over the entire expanse of both crop and sprout portions of the blueberry fields. At northern sites, nesting aggregations for these two species, although present, were difficult to locate and had significantly lower tunnel densities associated with them. Here, tunnel density for *A. regularis* and *A. vicina* averaged 7.6 ± 4.0 / m^2 (n=3 aggregations) and 6.3 ± 2.9 / m^2 (n=3 aggregations), respectively. Average tunnel depth for *A. regularis* was significantly shallower at these northern sites as compared to southern sites ($t=2.55$, $p<0.05$, $n=8$). Nest depth for *A. regularis* ranged from 8 to 19cm (mean 11.8 ± 3.2) and contained an average of 3.0 ± 0.7 (range: 1-5, n=8) cell per tunnel.

Andrena alleghaniensis nested aggregately in outwash areas within the blueberry fields. These areas consisted of a mixture of sand, pebbles and cobbles. Tunnel density was difficult to assess as nest entrances frequently were obscured with pebbles or shifting sand. Average tunnel density was 32 ± 7.5 / m^2 (n=3 aggregations). Tunnel depths ranged from 12 to 21cm (mean: 13.9 ± 4.3cm) extending into the sandy-loam layer beneath the sandy surface layer. Each tunnel contained only one or two natal cells and as such was much simpler than other *Andrena* nests evcavated. Although this species was collected from northern sites, its nesting sites were not located.

Andrena sp.1 (tentatively classified as *A. wilkella*) was only identified from the southern sites. Here, it nested in massive aggregations in areas of bare soil along the margins of the blueberry field. Tunnel density averaged 41 ± 15.4 / m^2 (n=4 aggregations) with a mean tunnel depth of 15.9 ± 1.7cm. Natal cell number per tunnel ranged from one to five (mean 3.5 ± 0.9).

The majority of bumblebee nests located during this study were in the woodland (1998: SE: n=7, NE: n=3; 1999: SE: n=10, NE: n=3). In this habitat nests were established in (1) abandoned mouse nests (7 *B. ternarius*, 6 *B. terricola*, 2 *B. vagans*, 1 *B. impatiens*) or (2) under or within decaying or fallen trees (3 *B. vagans*, 2 *B. fervidus*, 2 *B. perplexus*). Additional nests were located in Clear-cuts (1 *B. ternarius*, 1 *B. terricola*), Open Thickets (1 *B. ternarius*) and old field (1 *B. terricola*).

Foraging Flight Range. Of the total 1,120 bees marked at Jonah Mountain nesting sites during this study (24 April-15 June), 107 (19 *A. carlini*, *10 A. regularis*, 67 *A.* sp.1 and 11 *A. alleghaniensis*) were identified on forage. Figure 3 shows the distribution of marked-bee sightings on forage in relation to their nesting (marking) sites. Although all bees tested showed somewhat extended flight ranges, maximal foraging range, defined here as the greatest distance a foraging bee was observed from its nest, appeared to be related to body size. *A. carlini* (14mm) had the greatest foraging flight range at 1,250 metres. The two

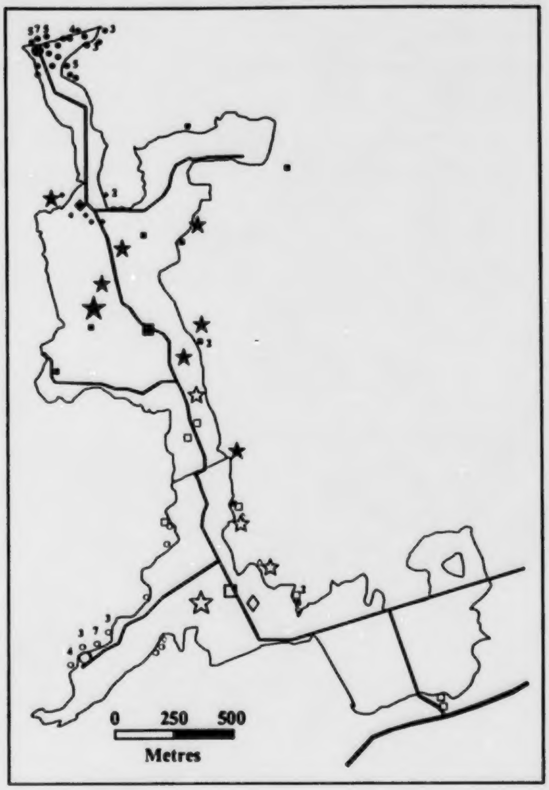


Fig. 3. Foraging flight ranges of four Andrenid bee species at Jonah Mountain. *A. carlini* (■ □), *A. regularis* (★☆), *A.* sp.1 (● ○), *A. alleghaniensis* (◆♬). Large icons = nesting sites (marking sites), Small icons = foraging sites (recapture sites), Solid icons = nesting within crop field, Open icons = nesting within sprout field. Numbers beside icons denote multiple sightings.

moderately sized species, *A. regularis* (11mm) and *A.* sp.1 (10mm), had maximal foraging distances of 925 and 675 metres, respectively. *A. alleghaniensis* (9mm), was observed no further than 410 metres from its nesting site.

The foraging flight range for each species in part reflected the seasonal propinquity of forage to nesting sites (Table 2). During the pre-*Vaccinium* bloom period, bees nesting centrally in the field exhibited relatively long minimal flight distances to access the only available forage which was scattered along the edge of the blueberry field (*A. carlini*: 375 metres, *A. regularis*: 275 metres, *A. alleghaniensis*: 80 metres). In contrast, bees (*A.* sp.1) nesting on the periphery were observed foraging within 5 metres of nesting sites. While *Vaccinium* was in flower, the average population foraging range of bees nesting in the crop portion of the field (*A. carlini*: 381 metres, *A. regularis*: 160 metres, *A.* sp.1: 65 metres and *A. alleghaniensis*: 33 metres) was less than their counterparts nesting in the sprout portion of the field (*A. carlini*: 655 metres, *A. regularis*: 925 metres, *A.*

Table 2. Foraging flight ranges of four *Andrena* species during the pre-*Vaccinium*, *Vaccinium* bloom and post-*Vaccinium* periods in relation to nesting sites within crop or sprout portions of the blueberry field at the Jonah Mountain study site

Andrena **Species**	**Nest Location in Blueberry Field (crop or sprout)**	**Foraging Range (nest/mark site → foraging/recapture site)**		
		Pre-*Vaccinium*	***Vaccinium* Bloom**	**Post-*Vaccinium***
A. carlini **(size: 14mm)**	Crop	Range: 375-1250 Mean: 754 n=4	Range: 25-825 Mean: 381 n=6	Range: N/A Mean: N/A n=N/A
	Sprout	Range: 410-1095 Mean: 790 n=3	Range: 350-1200 Mean: 655 n=5	Range: 850 Mean: N/A n=1
A. regularis **(size: 11mm)**	Crop	Range: 375-700 Mean: 583 n=3	Range: 25-350 Mean: 160 n=3	Range: 625 Mean: N/A n=1
	Sprout	Range: 275-400 Mean: 337 n=2	Range: 925 Mean: N/A n=1	Range: N/A Mean: N/A n=N/A
A. **sp. 1 (size: 10mm)**	Crop	Range: 20-300 Mean:115 n=20	Range: 5-210 Mean: 65 n=20	Range: N/A Mean: N/A n=N/A
	Sprout	Range: 50-320 Mean: 110 n=14	Range: 20-675 Mean: 170 n=13	Range: N/A Mean: N/A n=N/A
A. **sp. 2 (size: 8mm)**	Crop	Range: 80-110 Mean: 100 n=3	Range: 5-90 Mean: 33 n=4	Range: N/A Mean: N/A n=N/A
	Sprout	Range: 400-410 Mean: 405 n=2	Range: 175-200 Mean: 187 n=2	Range: N/A Mean: N/A n=N/A

sp.1: 170 metres and *A. alleghaniensis*: 187 metres). This indicates that many in-crop nesting bees took advantage of abundant forage relatively near their nesting sites while in-sprout nesting bees had to take extended foraging flights to reach the periphery of the field or the flowering portion of the blueberry field. Interesting, some bees nesting in-crop passed over *Vaccinium* to forage on alternative plants along the edge of the field. For example, *A. carlini* crossed a continuous *Vaccinium* cover and foraged on *Prunus virginiana* over 800 metres from its nesting site. Therefore, factors in addition to floral proximity, such as past experience and or floral preference, influence foraging flight range.

Natal cell production for *A. carlini* and *A. regularis* did not differ significantly within a given year between nesting sites located in the crop and nesting sites located in sprout portions of the field. For *A.*sp1, significant differences did exist (ANOVA: F=11.49; p<0.05, Tukey's HSD). In 1998, bees nesting adjacent the crop portion of the field (northern nest aggregation) had a significantly higher mean natal cell number per tunnel (4.2 ± 1.1) than bees nesting adjacent the sprout portion (southern nest aggregation)(3.1 ± 0.8). In 1999, overall natal cell production at the site was slighter lower overall. However, bees adjacent the crop portion of the field (southern nest aggregation this year) had significantly more cells per tunnel (3.9 ± 0.8) than did bees adjacent the sprout portion (northern nest aggregation this year) of the field (2.0 ± 0.9). The limited flight range of this species precluded it from foraging at *Vaccinium*. Although this site had relatively high floral abundance along the Forest Edge, exclusion from *Vaccinium* (the most abundant floral source for approximately 40% of *Andrena* life span) reduced the reproductive output of this bee.

Spatio-Temporal Abundance and Distribution of Flowering Plants. Site-wide floral volume was highly variable among study sites (Figure 4). During both the pre-*Vaccinium* and post-*Vaccinium* periods, southern sites had higher floral volumes than the northern sites. During the *Vaccinium* flowering period, all study sites achieved their highest seasonal floral volumes resulting from the size and floral densities of commercial blueberry fields housed within them.

A total of 50 plant species were identified as bee forage from the four wild blueberry agro-ecosystems surveyed during this study (April-September). Overall floral composition at each study site depended on the number of habitats present, as distinct habitats housed specific floral assemblages. Wild Flower areas and Open Thickets were the most speciose habitats at 25 and 22, respectively. Although both of these habitats had similar species richness, the combined flowering phenologies of 22 species in the open thicket made it the only habitat to provide continuous bee forage over the duration of the study period. Floral assemblages within Wild Flower areas commenced flowering, in any substantial way, after the *Vaccinium* bloom. From this point until the end of the study period, this habitat provided continuous bloom. In contrast, the 12 plant species along the forest edge flowered prior to and/or during the *Vaccinium* bloom. Therefore, Forest Edge and Open Thickets were the only habitats that were a source of bee forage during the pre-*Vaccinium* flowering period. Both these habitats also bloomed concurrently with *Vaccinium*. Recent forest clearings and woodlands contained few flowering plants and thus must be considered of little importance as foraging areas for bees. Figure 5 shows the seasonal distribution of floral resources among habitats from each study site.

1. Pre-*Vaccinium*. Prior to the *Vaccinium* bloom period, site-wide floral volume at SE_1 (430 ± 184.3) was higher than at any of the other sites. The main reason for this was relatively high floral abundance within two habitats, Open Thicket and Forest Edge. The Open Thicket provided 53.2% of bee forage at this site with an average floral density of 2,863 ± 1,286. Slightly lower amounts of forage (46.3%) were found along the Forest Edge (floral density: 3,986 ± 1,599). Although both these habitats were present at SE_2 and NE_1, site-wide floral volume at these sites (SE_2: 242.9 ±127.6; NE_1: 206 ± 66.3) ranked below that of SE_1. At SE_2, 90.3% of all flowering plants were found in the Open Thicket (64.4%) and Forest Edge (25.9%) with corresponding floral densities of 1,562 ± 771 and

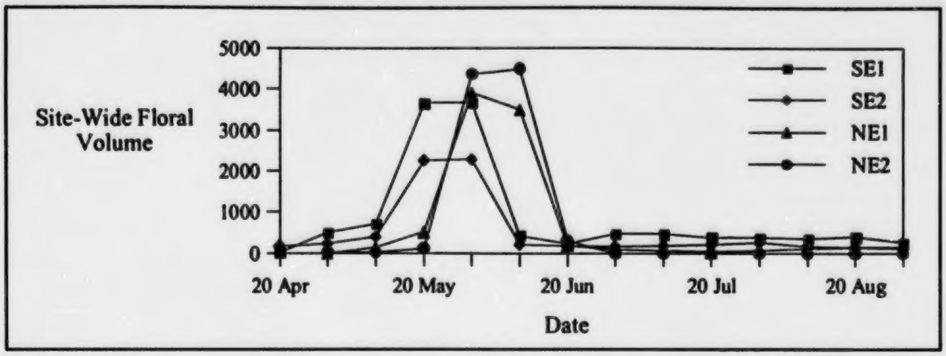


Fig. 4. Comparison of seasonal site-wide floral volume among study sites.

2,089 ± 942, respectively. At NE_1, 98.6% of bee forage was confined to the Forest Edge (62.9%) and Open Thickets (35.7%). Average floral densities in these habitats were 2,590 ± 1,599 and 1,478 ± 930, respectively. At NE_2, most of the flowering plants (97.3%) during this period were confined to a single habitat; the Forest Edge. Even though this habitat at NE_2 occupied a similar proportion of the study are as compared to the other study sites, low numbers of flowering trees and shrubs resulted in very low floral abundance (mean: 612 ± 345). As such, site-wide floral volume (19.8 ± 11.3) was the lowest observed among study sites.

During this period, primary floral resources were expressed as sequentially flowering trees and shrubs (*Acer rubrum* → *Salix* / *Corylus*→ *Amelanchier*) unevenly distributed along the woodland border (Edge) and scattered throughout the Open Thicket. This created isolated pockets of bloom within study areas that concentrated the foraging activity of bees resulting in relatively high bee densities in both these habitats.

2. *Vaccinium* bloom. During the *Vaccinium* bloom, commercial blueberry fields, Forest Edges and Open Thickets provided forage for bees. At all sites, the commercial blueberry field was by far the most abundant source of bee forage. As such, the relative percentage of the study site covered by commercial blueberry field was the primary factor that determined floral availability within a study area during this time of year. At SE_1, average site-wide floral volume was 2,120 ± 1,840. Here, the commercial blueberry field averaged 75.4% of forage within the study area with an average floral density of 5,625 ± 9,079 (range: 369-19,447) over the course of its bloom. At peak *Vaccinium* bloom, the commercial blueberry field accounted for as much as 85.6% of bee forage within the study area. Open Thickets and Forest Edges provided 15.5% and 8.7% of forage, respectively. Both these habitats maintained significant floral densities while *Vaccinium* was in bloom (Open Thicket: mean: 4,127 ± 347, range: 1,320-5,210; Edge: mean: 3,729 ± 1,770, range: 3,920-4,645).

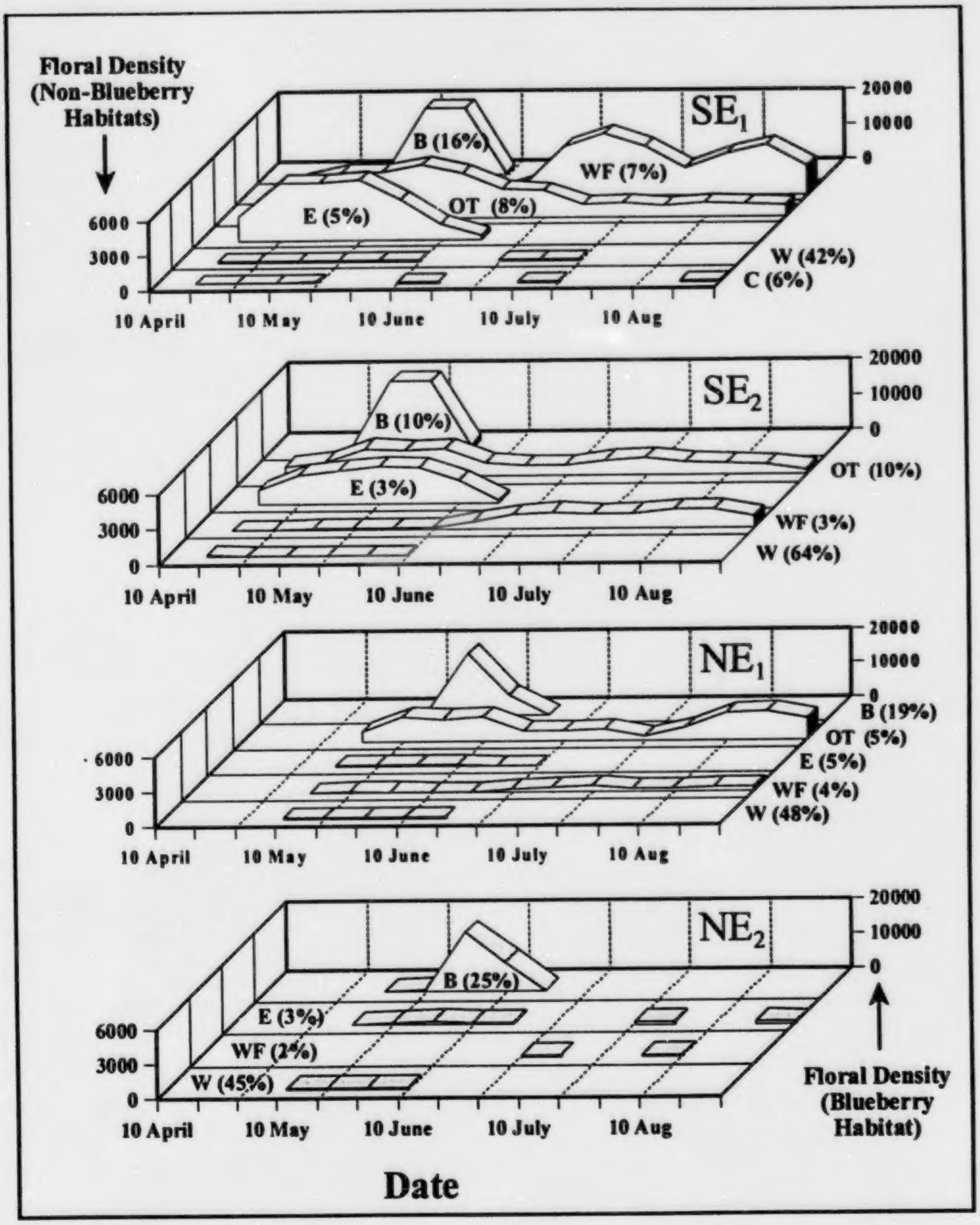


Fig. 5. Seasonal distribution of floral resources among habitats within study sites. B = commercial blueberry field, OT = Open Thicket, E = Edge, WF = Wild Flower Areas, W = Woodland, C = Clear-Cut. Numbers in parenthesis indicate the percentage of the study area occupied by the habitat.

Site-wide floral volume at SE_2 was 1,292 ± 1,184. Although the commercial blueberry field was still the main floral resource at this site, providing 77.0% of forage, the relatively lower percentage occupied by this habitat at this site reduced the site-wide floral volume. At peak Vaccinium bloom the commercial blueberry field at this site accommodated 85.6% of bee forage. The Forest Edge and Open Thickets provided 6.2% and 15.5% of bee forage during the *Vaccinium* flowering period. Average floral density in the commercial blueberry field was 9,966 ± 10,898 (range: 437-19,448). Average floral densities were similar in Open Thickets (mean: 2,040 ± 620, range: 1,118-2,425) and along Forest Edges (mean: 2,700 ± 564, range: 1,875-3,111).

During this period NE_1 had a similar site-wide floral volume (1,919 ± 1,987) to SE_1. However, at this site, the commercial blueberry field contained a much higher percentage (average: 88.5%, peak: 94.0%)of total bee forage within the study area. Average *Vaccinium* floral density was 8,953 ± 10,204 (range: 102-18,241). The Forest Edge and Open Thickets provided an average of 5.6% (mean floral density: 2,403 ± 802, range: 1,291-3,007) and 5.5% (mean floral density: 2,161 ± 243, range: 1,24-2,500) of bee forage.

At NE_2, site-wide floral volume was the highest among all study sites (2,307 ± 2,475). At this site, the commercial blueberry field occupied 25% of the study area; the most among all study site. This site differed from all other sites in that a very high percentage (99.6%) of all bee forage with the system was confined to the commercial blueberry field (mean floral density: 9,195 ± 9,982, range: 59-18,000). Few flowering trees and shrubs along the Forest Edge resulted in very low floral density (mean: 77 ± 66, 11-120) with only 0.4% of forage found in this habitat.

During this period blueberry was the most abundant flowering species as monocultural fields dominated each study site. Open Thickets and Forest Edges provided many similar floral choices over this period. Sequentially blooming *Amelanchier* (late bloom) → *Prunus pensylvanica* → *Prunus virginiana* along with *Rhododenderon* (mid to late bloom), *Rubus* (Blackberry), *Kalmia angustifolium* and *Vaccinium* were primary forage species.

3. Post-*Vaccinium*. The forest edge at three of the study sites (SE_1, SE_2 and NE_1) provided forage for 7-10 days following *Vaccinium* flowering. The most important plant species were *Sorbus americana* and *Acer Spicatum*. With the exception of this brief flowering period along the forest edge, the main forage habitats after the *Vaccinium* bloom were open thicket and wild flower areas. The primary forage plants associated with Wild Flower areas were *Viccia cracca*, *Spirea latifolia*, *Hypericum perforatum*, *Epilobium angustifolium*, *Trifolium pratense*, *Trifolium repens*, *Medicago lupulina*, *Solidago* spp. and *Aster* spp. In Open Thickets, *Rubus* spp. (blackberry and raspberry), *Kalmia angustifolium*, *Spirea latifolia*, *Rosa* spp., *Solidago* spp. and *Aster* spp provided the main sources of forage over the post-*Vaccinium* period.

At SE_1, site-wide floral volume was significantly higher than the other study sites (375.4 ± 147.5). Primary floral availability at this site was divided Wild Flower areas (62.9%) and Open Thickets (30.2%). Floral density in Wild Flower areas ranged from 999 to 5,381 (mean: 3,476 ± 1,412) and from 947 to 2,441 (mean: 1,415 ± 599) in Open Thickets. At SE_2, side-wide floral volume ranked second among study sites (136.8 ± 43.0). In contrast to SE_1, the majority of bee forage, 72.8%, was in Open Thickets (mean floral density: 998 ± 319, range 440-1,478)). Wild Flower areas provided 26.6% of bee forage with mean floral density of 1,204 ± 304 (range: 640-1,571).

During the post-*Vaccinium* period site-wide floral volume at NE_1 (98.7 ± 56.5) was significantly lower than the Southern sites. Wild Flower areas, although only comprising four percent of the study area, provided 83% of the bee forage at this site. Floral density in this habitat average 1,657 ± 865 (range: 320-2,496). Open Thickets provided only 12.7% of bee forage as a result of relatively low floral density (mean: 310 ± 105, range: 20-378). Following the *Vaccinium* bloom floral availability at NE_2 was negligible. Site-wide floral volume was 1.1 ± 1.0. At this site, 82% of forage was found within Wild Flower areas and along the Forest Edge. Combined floral density from these habitats was 26.5 ± 24.1 (range: 0-54).

Spatio-temporal Abundance and Distribution of Bees. Although considerable differences existed among all sites, southern region sites had significantly higher site-wide seasonal bee volume than northern sites (Figure 6). The response of bee populations to seasonal floral availability within study areas resulted in two distinct patterns of abundance. First, bee abundance at both Northeast sites peaked in early June (*Vaccinium* bloom) followed by relatively low numbers showing little variance until September. In contrast, bee populations at the Southeast sites had a bimodal seasonal distribution. Indigenous bee abundance was highest during the *Vaccinium* flowering period followed by a second, lesser, peak in mid July. This second peak was only associated with sites containing abundant post-*Vaccinium* forage. At these sites *Bombus* workers were the primary component of overall abundance at this time. Observations from eight wild blueberry agro-ecosystems (four in the Southeast and four in the Northeast) showed a significant linear relationship between peak number of *Bombus* workers during the summer and *Bombus* queen abundance the following spring ($r = 89.3$, $p>0.05$)(Figure 7). Although the highest numbers of summer workers and spring queens were observed from southern sites, this relationship appeared to have little to do with geographic location. If forage was available during mid summer at northern sites, summer workers and corresponding spring queens often ranked above some of the southern sites.

The seasonal distribution of bees among various habitats within each study site was generally linked to the distribution of floral resources. Figure 8 shows the seasonal foraging density of bee populations among habitats from each of the study sites.

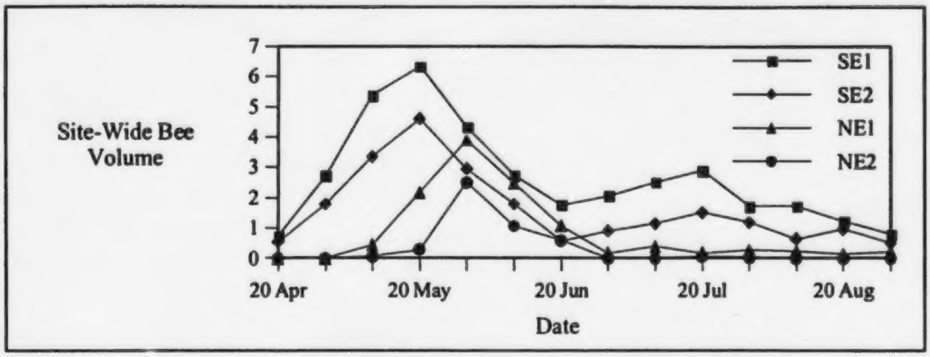


Fig. 6. Comparison of seasonal site-wide bee volume among study sites.

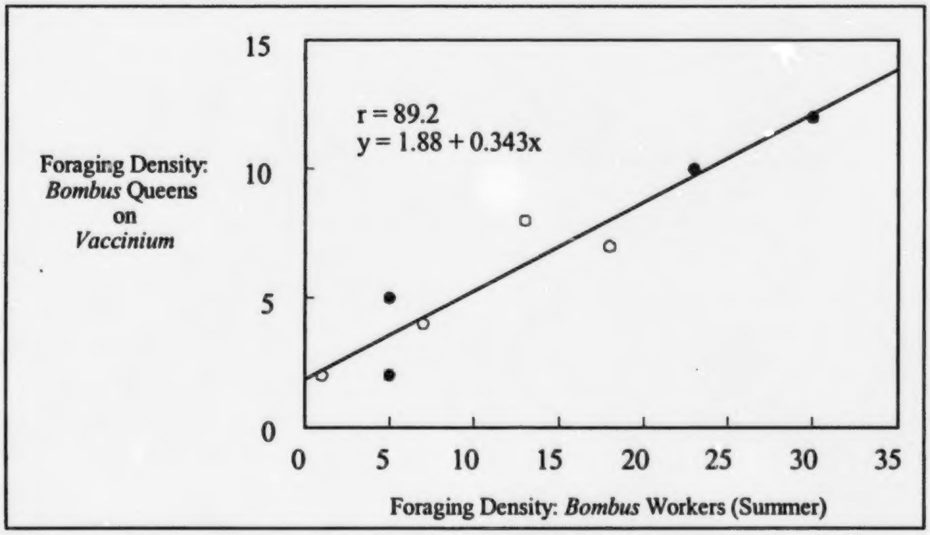


Fig. 7. Scattergram showing the relationship between the foraging density of *Bombus* workers in the summer and the foraging density of *Bombus* Queens on *Vaccinium angustifolium* the following spring. (Foraging Density: 1×20 metres / 5 minutes). Solid circles: SE, Open circles: NE.

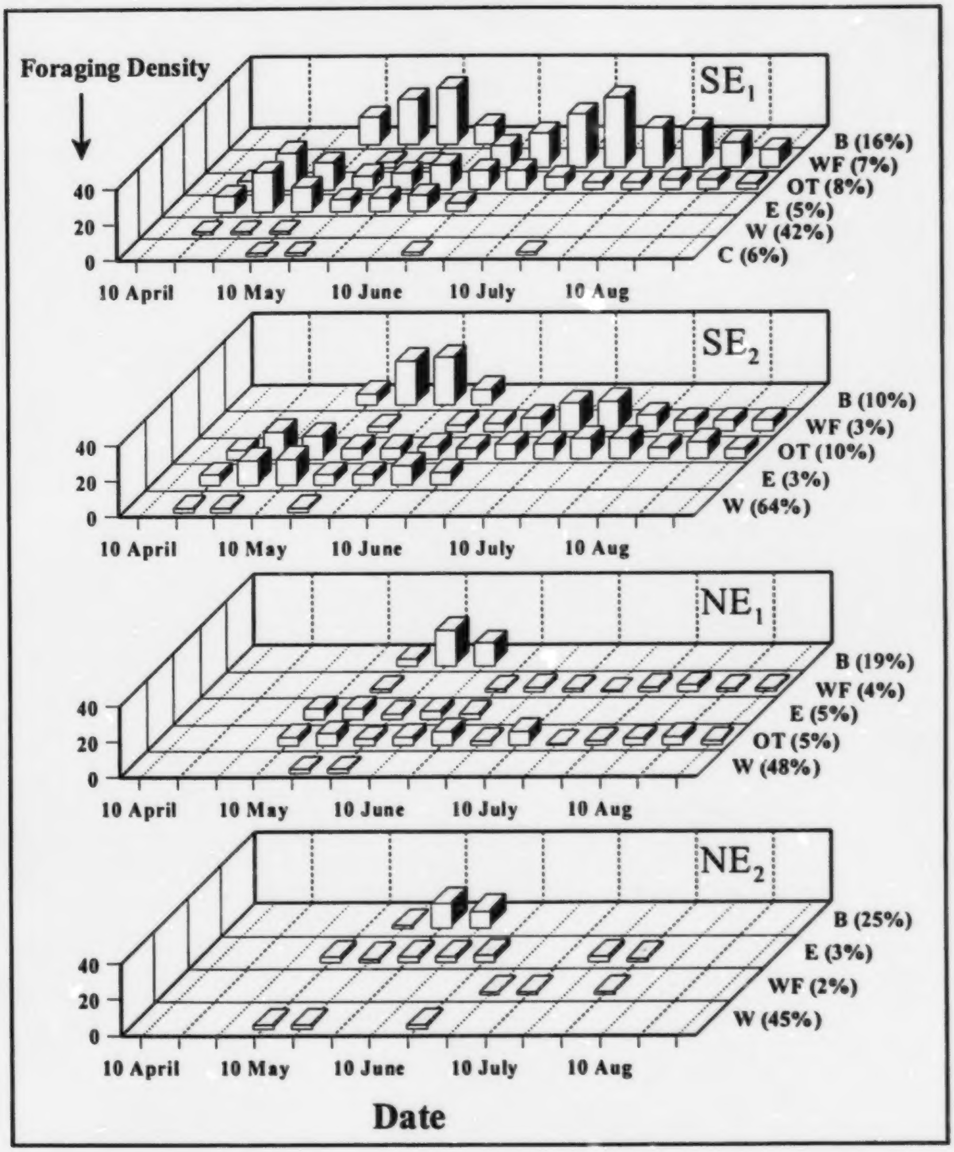


Fig. 8. Seasonal distribution of foraging bees among habitats within study sites. B = commercial blueberry field, OT = Open Thicket, E = Edge, WF = Wild Flower Areas, W = Woodland, C = Clear-Cut. Numbers in parenthesis indicate the percentage of the study area occupied by the habitat.

1. Pre-*Vaccinium*. During the pre-*Vaccinium* flowering period the pollinator guild within the wild blueberry agro-ecosystem was composed primarily of the indigenous taxa *Andrena*, *Bombus* (queens) and Halictids. Although Osmiine bees and the parasitic taxa *Psithyrus*, *Nomada* and *Sphecodes* were recorded from each study site, their abundance was low.

Site-wide foraging bee volume at SE_1 was 2.32 ± 1.1 composed of 64% *Andrena*, 19.4% Halictids and 16.6% *Bombus* queens. During this period, 37.4% of the bees were recorded from the Open Thicket. The foraging density in this habitat averaged 14.0 ± 8.6 with a relative abundance of 48.0% *Andrena*, 25.7 % Halictids and 25.7% *Bombus* queens. At this site, 60.6% of bees foraged along the Forest Edge (relative abundance: 74% *Andrena*, 10.6% Halictids and 15.1% *Bombus* queens) with an average foraging density of 21.6 ± 8.0.

At SE_2, foraging bee volume prior to the *Vaccinium* bloom averaged 1.44 ± 0.73 (relative abundance: 46.6% *Andrena*, 29.7% *Bombus* queens, 23.7% Halictids). At this site, 51.1 % of bees foraged in the relatively large Open Thicket (10% of study area) with an average foraging density of 11.2 ± 6.1 composed of 33.0% *Andrena*, 44.6% *Bombus* queens and 22.4% Halictids. Although smaller than Open Thickets in relative size, 48.5% of bees foraged along the Forest Edge (3% of study area). The average foraging density in this habitat during this period was12.7 ± 3.9 composed of 60.7% *Andrena*, 14.0% *Bombus* queens, 25.3% Halictids.

Site-wide bee volume at NE_1 (0.57 ± .25) was significantly lower than at both southern sites. Overall composition of the pollinator guild was 35.1% *Andrena*, 32.5% Halictids and 32.4% *Bombus* queens. Bee occurrence between the two primary forage-yielding habitats at this site was similar. 50.8% of bees were recorded from the Forest Edge (foraging density: 5.9 ± 1.9; relative abundance: 42.3% *Andrena*, 28.8% *Bombus* queens, 28.9% Halictids) and 49.2% from the Open Thicket (foraging density: 5.5 ± 2.9; relative abundance: 35.1% *Andrena*, 32.4% *Bombus* queens, 32.5% Halictids).

At NE_2, site-wide bee volume was the lowest among all study sites (0.13 ± 0.08). Here, available forage was restricted to only one habitat; the Forest Edge. The average foraging density during the pre-*Vaccinium* flowering period averaged 4.2 ± 2.8 with relative abundance dominated by Halictids (62.0%). *Andrena* and *Bombus* queens made up 23.8% and 14.2% of the pollinator guild, respectively.

2. *Vaccinium* bloom. The taxonomic richness of the pollinator guild expanded from three to five over the course of the *Vaccinium* flowering period. The initial *Andrena* / *Bombus* queen / Halictid composition was supplemented with (1) the introduction of *Apis mellifera* at early bloom and (2) the appearance of the *Bombus* worker class from mid to late bloom.

At SE_1, site-wide bee volume was 6.14 ± 2.4. Overall relative abundance at this site was 32.4% *Andrena*, 25.4% *Bombus* queens, 23.2% Halictids, 16.7% *A. mellifera* and 2.3% *Bombus* workers. Almost three-quarters (72.1%) of the bees at SE_1 foraged on the commercial blueberry field. The average foraging density within this habitat was 27.7 ± 11.2 with *Bombus* queens (30.6%) and *Andrena* (27.0%) being the most abundant pollinators followed by Halictids (24.5%), *A. mellifera* (16.2%), and *Bombus* workers (1.7%). The Open Thicket accommodated 16.7% bees at this site with an average foraging density of 12.9 ± 4.8. *Andrena* (33.3%) was the most abundant taxa followed by *Bombus* queens (25.6%), Halictids (21.7%), *A. mellifera* (17.8%) and *Bombus* workers (1.6%). Within the study area, 11.0% of the bees foraged along Forest Edge habitat. The average foraging density along the forest edge was 13.6 ± 4.73 composed of 42.6% *Andrena*, 22.1% Halictids, 16.9% *A. mellifera*, 14.7% *Bombus* queens, and 3.7% *Bombus* workers.

SE_2 had the second highest site-wide bee abundance during this period averaging 3.6 ± 1.9 with a an overall relative abundance of 34.2% *Andrena*, 28.1% *Bombus* queens, 20.4% *A. mellifera*, 13.6% Halictids and 3.5% *Bombus* workers. Here, 47.9% of bees foraged on the commercial blueberry field with an average foraging density of 21.8 ± 11.6 composed of 32.1% *Andrena*, 34.4% *Bombus* queens, 19.7% *A. mellifera*, 10.1% Halictids and 4.0% *Bombus* workers. The relatively large Open Thicket habitat at this site provided forage for 21.1% of bees during this period. *Andrena* (29.1%) and *Bombus* queens (23.9%) and *A. mellifera* (28.1%) were equally represented in this habitat followed by Halictids (15.6%) and few *Bombus* workers (3.3%). 31.0% of bees at this study site foraged along the Forest Edge. The relative abundance of bees in this habitat was 41.1% *Andrena*, 21.2% *Bombus* queens, 17.7% Halictids, 15.8% *A. mellifera* and 4.2% *Bombus* workers.

At NE_1, site-wide bee abundance was 3.1 ± 1.8. *A. mellifera* was the most abundant pollinator (41.9%) followed by *Andrena* (27.1%), Halictids (16.1%), *Bombus* queens (12.7%) and *Bombus* workers (2.5%). Over three-quarters of bees (82.5%) at this study site foraged on the commercial blueberry field with an average foraging density of 13.5 ± 7.5. Relative abundance in this habitat was 40.7% *A. mellifera*, 28.8% *Andrena*, 13.3% Halcitids, 14.8% *Bombus* queens and 2.4% *Bombus* workers. 9.0% of bees foraged in the Open Thicket habitat with an average density 5.5 ± 3.8 composed of 37.5% *A. mellifera*, 23.2% *Andrena*, 21.4% Halictids, 12.5% *Bombus* queens and 5.4% *Bombus* workers. Only 8.5% of bees within this system foraged along the Forest Edge. The foraging density within this habitat was 4.5 ± 3.3 with a relative abundance of 49.7% *A. mellifera*, 26.6% *Andrena*, 17.7% Halictids, 6.0% *Bombus* queens with no *Bombus* workers observed.

At NE_2, site-wide bee abundance was the lowest among study sites (2.7 ± 1.8). The commercial blueberry field was the main source of forage within the system. As such, 98.1% of bees were recorded from this habitat. The foraging density of bees averaged 10.6 ± 6.9 and was heavily dominated by *A. mellifera* (42.4%) with indigenous pollinators poorly represented (*Andrena* (18.8%), Halictids (21.6%), *Bombus* queens 14.1% and *Bombus* workers (3.1%)).

3. Post-*Vaccinium*. At the end of the *Vaccinium* flowering period *A. mellifera* colonies were removed from the study sites leaving a pollinator guild composed entirely of indigenous bees. Shortly after the cessation of *Vaccinium* bloom (1) *Andrena* seasonal activity ceased and (2) *Bombus* queen abundance steadily declined as queens remained on the nest leaving the foraging responsibilities of the colony to the workers (see bee phenology). Following this, the pollinator guild was composed of *Bombus* workers, Halictids (only some of which were associated with blueberry pollination), Megachilids and Osmiine bees not associated with blueberry pollination.

At SE_1, site-wide bee foraging bee volume averaged 2.07 ± 1.24 and was composed predominantly of *Bombus* workers (67.7%) followed by Megachildae (18.6%), Halictids (8.4%) *Bombus* queens (3.0%) and *Andrena* (2.3%). 72.5% of bees at this site were recorded from Wild Flower areas with an average foraging density of 21.9 ± 12.1 (relative abundance: 65% *Bombus* workers, 19.3% Megachilidae, 14.0% Halictids, 1.0% *Bombus* queens and 0.7% *Andrena*). The Open Thicket accommodated 24.1% of bees with an average foraging density of 6.9 ± 4.5 (relative abundance: 52.2% *Bombus* workers, 21.8% Halictids, 17.4% Megachilidae, 7.2% *Bombus* queens, 1.4% *Andrena*). Flowering plants along the Forest Edge were only present in abundance for a short time following the *Vaccinium* flowering period. Here, bee foraging density averaged 1.3 ± .8 and was composed of 38.4% *Andrena*, 30.8% *Bombus* workers, 23.1% Halictids and 7.7% *Bombus* queens.

The site-wide foraging bee volume at SE_2 was 1.0 ± 0.55 (relative abundance: 61.9% *Bombus* workers, 20.9% Megachilidae, 15.2% Halictids, 1.6% *Bombus* workers and 0.3% *Andrena*). 71.0% of bees utilised the Open Thicket with an average foraging density of 7.2 ± 4.0 (relative abundance: 64.8% *Bombus* workers, 18.0% Halictids, 15.2% Megachilidae, 1.6% *Bombus* queens, 0.3% *Andrena*). 26% of bees foraged in Wild Flower areas. Average foraging density within this habitat was 8.6 ± 5.2 composed of 59.6% *Bombus* workers, 25.6% Megachilidae, 12.8% Halictids, 1.6% *Bombus* queens and 0.4% *Andrena*. Only 3% of bees foraged along the forest Edge during this period.

Site-wide foraging bee volume in NE_1 averaged 0.29 ± .21 (relative abundance: 62.5% *Bombus* workers, 19.0% Megachilidae, 15.5% Halictids, 2.1% *Bombus* queens, 0.9% *Andrena*). This was significantly lower than the Southern sites. During this period almost two-thirds of the bees within this system were recorded from the Open Thicket. Bee density in this habitat averaged 3.5 ± 2.6, consisting of 69.4% *Bombus* workers, 16.3% Halictids, 12.3% Megachilidae, 1.3% *Bombus* queens and 0.7% *Andrena*. The Wild Flower areas at this site had 34% of foraging bees with an average foraging density of 2.6 ± 1.7 (relative abundance:

49.2% *Bombus* workers, 24.6% Halictids, 23.2% Megachilidae, 2.1% *Bombus* queens and 0.9% Andrena). Relatively few bees (4%) were recorded from the Forest Edge.

Following the *Vaccinium* flowering period very low numbers of bees were recorded from the NE_2 study site. During this period, site-wide bee volume averaged 0.2 ± 0.3; the lowest among all study sites. Here, all bees were recorded from along the Forest Edge. Average foraging density was 0.65 ± .85 composed primarily of Halictids (87.6%). Megachilids, *Bombus* workers and *Andrena* combined made up 12.4% of bees. *Bombus* worker abundance was conspicuously lacking from this site as they composed only 7.6% of bees during this period.

Taxonomic Patterns of Habitat Utilization. If bees do not discriminate among habitats, it can be assumed that the presence of foraging bees in a given habitat will be proportional to the percentage of the total site-wide floral abundance within that habitat.

1. **Pre-*Vaccinium*.** During the pre-*Vaccinium* flowering period, the proportional representation of *Andrena* foraging among habitats differed significantly from expected values based on site-wide floral availability (χ^2=75.8, df=5, p< 0.005). During this time of the year, Forest Edges and Open Thickets were the primary foraging habitats within study areas. Each of these habitats contained similar floral assemblages. Despite this, a disproportionate number of *Andrena* foraged along the Forest Edge. Pooling data from all study sites, the Forest Edge accommodated 43% of site-wide floral availability, but contained 65% of foraging *Andrena*. Although Open Thickets had 51% of site-wide forage, only 34% of *Andrena* utilized this habitat. In contrast, the foraging distribution of *Bombus* queens was proportional to habitat-specific floral availability (χ^2=6.7, df=5). Data polled from all study site showed that 39% of *Bombus* queens foraged along the Forest Edge (43% of available forage) and 59% foraging in Open Thickets (51% of available forage).

2. ***Vaccinium* bloom.** During the *Vaccinium* flowering period, the distribution of *Andrena* among habitats was not proportional to the distribution of floral resources (χ^2=53.2, df=8, p<0.005). Approximately 29% of *Andrena* foraged along the Forest Edge although it contained only 16% of available forage. Open Thickets had 20% of foraging *Andrena* (15% forage) and the Commercial Blueberry Fields had 48% of *Andrena* (66% forage). Although *Andrena* disproportionately used available forage, the vast majority was found on Commercial Blueberry Fields. The distribution of *Bombus* queens among habitats was proportional to the occurrence of floral resources (χ^2=14.5, df=8). Data polled from all study sites shows that 62% of *Bombus* queens foraged on Commercial Blueberry (66% forage), 15% along Forest Edges (16% forage) and 21% in Open Thickets (20%). *A. mellifera* displayed a disproportional use of floral resources while *Vaccinium* was in flower (χ^2=39.7, df=8, p<0.005). Although the Commercial blueberry Field habitat provided 66% of site-wide

forage, an average of only 49% (range: 42 to 55%) of honeybees introduced at study sites actually foraged on the crop. An average of 24% of honeybees foraged along Forest Edges (16% forage) and 25% foraged in Open Thickets (20% forage).

The foraging density of indigenous bees on commercial blueberry fields was positively related to the site-wide volume of bees in non-*Vaccinium* habitats ($r=0.790$) (Figure 9). Sites that accommodated larger populations of indigenous bees in other habitats tended to have higher foraging densities on the crop. As such, bees foraging in other habitats cannot be considered detrimental to commercial blueberry pollination. Geographic location of wild blueberry agro-ecosystems had little bearing on this relationship.

3. Post-*Vaccinium*. During the post-*Vaccinium* period, Open Thickets and Wild Flower areas were the two primary forage habitats within wild blueberry agro-ecosystems. At sites were both these habitats occurred; *Bombus* workers foraged disproportionately in Wild Flower areas ($\chi^2=52.7$, df=5, $p< 0.005$). Data pooled from three study sites (SE_1, SE_2 and NE_1), showed that 66% of *Bombus* workers foraged in Wild Flower areas (57% forage), whereas only 30% foraged in Open Thickets (40% forage).

Taxonomic Patterns of Floral Use. The analysis of pollen loads throughout the study period were used to determine the most important forage plants being utilized by populations of *Andrena* and *Bombus* at each of the study sites.

1. Pre-*Vaccinium*. Pooled pollen loads of *Andrena* collected at nesting sites at $SE_1$and SE_2 averaged 80% *Salix*, 14% *Acer*, 1% *Corylus* and 5% unidentified pollen on 20 April (n=23) and 74% *Amelanchier*, 14 % *Acer* 7% *Salix* and 11% unidentified pollen on 10 May. Only 34.7% (n=8) of pollen loads examined from 20 April showed >99% pollen of a single species whereas 35% from 10 May contained >99 single source pollen (*Amelanchier*). *Bombus* pollen loads (n=9) contained 59% *Salix*, 24% *Acer* and 17% unidentified pollen (20 April) and 64% *Amelanchier*, 14% *Acer*, 7% *Salix* and 15% unidentified pollen. No pure loads were observed. Pollen loads from *Andrena* captured at northern sites contained an average of 93% *Salix*, 7% unidentified pollen (10 May) and 72% *Amelanchier*, 8% *Rhododenderon*, 7% *Salix*, 1% *Ledum* and 12% unidentified pollen (20 May)

For *Bombus* queens, pollen loads contained an average of 84% *Salix*, and 16% unidentified pollen (10 May) and 64% *Amelanchier*, 14% *Salix*, 9% *Rhododenderon* and 13% unidentified pollen (20 May).

2. *Vaccinium* flowering period. During the *Vaccinium* flowering period pollen loads from *Andrena* captured returning to nests at Southern study sites contained *Vaccinium* (54%), *Prunus* (23%), *Amelanchier* (6%), Rosaceae (4%), *Acer* (3%)

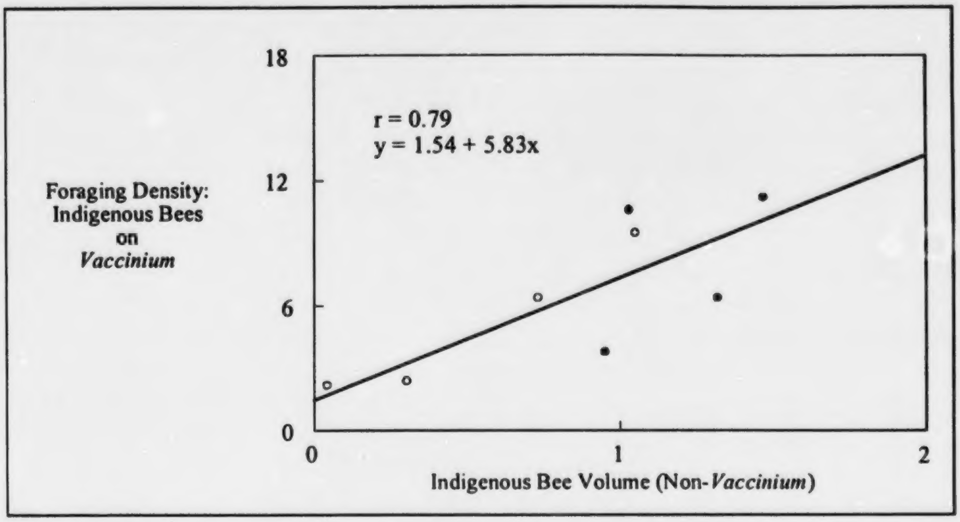


Fig. 9. Scattergram showing the relationship between indigenous bee volume in non-*Vaccinium* habitats during *Vaccinium* bloom and the foraging density of indigenous bees on commercial blueberry fields. Solid Circles: SE, Open Circles: NE.

unidentified (10%) (SE_1: n=19 bees; SE_2: n=11 bees). Of the 30 individuals examined, 9 carried pure pollen loads (> 90% single source pollen). Six of the pure pollen loads were *Vaccinium*, two were *Prunus* and one was *Amelanchier*. Pooled pollen loads collected from 23 *Andrena* at the Northern sites contained *Vaccinium* (61%), *Prunus* (27 %), *Amelanchier* (1%) and unidentified pollen (11%). Of the bees examined, four carried pure pollen loads (*Vaccinium*: 2, *Prunus*: 2).

Pollen loads taken from *Bombus* queens returning to nests at Southern sites contained *Vaccinium* (61%), Prunus (18%), Rosaceae (8%), Amelanchier (2%) and unidentified (11%) (pooled data: n=9). At northern site, pollen loads contained *Vaccinium* (67%), *Prunus* (24%), and 8% unidentified (pooled data, n=5). Of the 14 *Bombus* queens examined, only one contained a pure pollen load (*Vaccinium*).3.

3. Post-*Vaccinium*. In early July, 11 *Bombus* workers with pollen loads were captured within the woodland habitat at SE_1. Pooled data from all bees contained the following relative percentages of constituent taxa: 37% *Vicia*, 18% *Trifolium*, 13% *Hypericum*, 8% *Melilotus*, 3% Rosaceae and 21% unidentified. Two bees contained pure *Vicia* pollen loads.

Discussion

In the most basic sense, ecosystems must provide sufficient nesting sites from which indigenous bees can access adequate forage resources over the span of individual or colonial life cycles. Habitat utilized by bees can be classified as "entire", where all required resources (nesting sites and foraging areas) are contained within a single habitat, or "partial", where the required resources are found in two or more distinct habitats. This study shows that both *Andrena* and *Bombus* require a series of partial habitats over the course of their seasonal activity periods. When flowering plant populations were separated into habitat specific categories it was apparent that floral availability was unevenly distributed, both spatially and temporally, throughout the study areas. These habitat-linked floral assemblages resulted in not only the need for bee populations to exploit a changing array of forage plants, but to switch between several different habitats during seasonal activity periods. These foraging habitats were, for the most part, mutually exclusive from nesting habitats, with the exception of the brief period when *Andrena* both nested and foraged within blueberry fields. As a result, a diverse landscape mosaic is essential to accommodate indigenous bees.

In order to design wild blueberry agro-ecosystems to accommodate indigenous bees, the relationship of any bee taxa with its surrounding ecosystem must first be placed in context by establishing the time frame of the interaction. Secondly, taxa-specific habitat requirements (foraging and nesting areas) must be provided over this time period. Although often linked by their commonality as important pollinators of *Vaccinium angustifolium*, this study shows that the seasonal patterns of habitat utilization of *Andrena* and *Bombus* are markedly different. These patterns of contact among habitats are summarized in Figures 10 and 11.

In non-anthropogenic environments *Andrena* spp. take advantage of areas of bare soil created through natural successional processes or perennial clearings such as meadows. The creation and subsequent management practices applied to blueberry fields, in essence, keep these areas in a constant state of early succession, thus providing potentially large nesting habitat for *Andrena*. Within wild blueberry agro-ecosystems *Andrena* nesting sites are generally restricted to both the crop and sprout portions of blueberry fields and the dirt roadways traversing them. By definition, Blueberry Field habitat is a component of all wild blueberry agro-ecosystems. However, the acceptability of blueberry fields as nesting sites is determined by a number of factors. First, the type of soil underlying these habitats must meet the nesting substrate requirements of the bees. At southern sites, the sandy-loam / sandy-clay-loam substrate underlying the entire study sites provided a desirable nesting substrate for seven of the eight *Andrena* species identified. This allowed bees, when other micro-environmental nesting criteria were met, to establish nests throughout the entire blueberry fields. The soil underlying northern sites was much sandier in composition. Lower site-

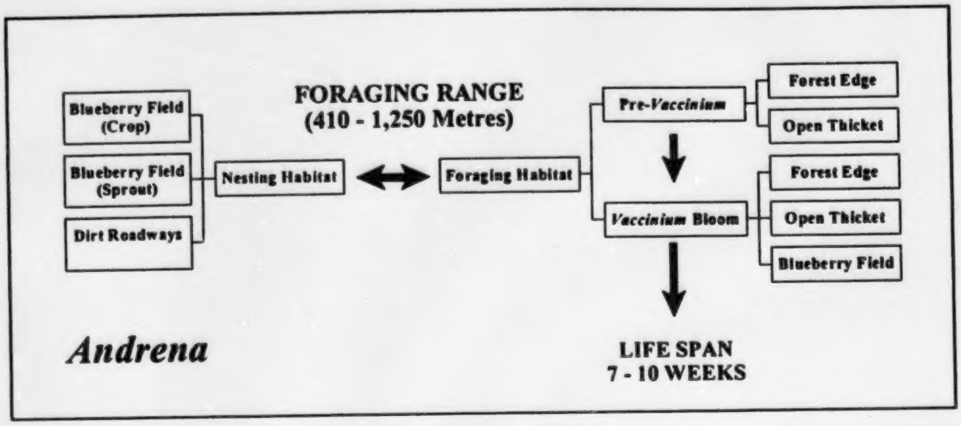

Blueberry Field (Crop)
Blueberry Field (Sprout)
Dirt Roadways
Nesting Habitat
FORAGING RANGE (410 - 1,250 Metres)
Foraging Habitat
Pre-*Vaccinium*
Vaccinium Bloom
Forest Edge
Open Thicket
Forest Edge
Open Thicket
Blueberry Field
Andrena
LIFE SPAN 7 - 10 WEEKS

Fig. 10. Seasonal patterns of habitat utilization by *Andrena* within the New Brunswick wild blueberry agro-ecosystem.

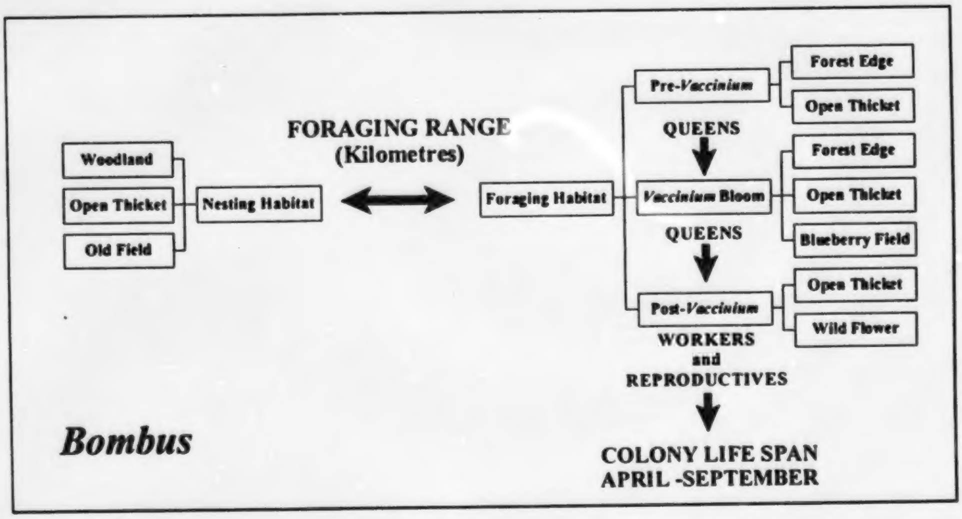

Woodland
Open Thicket
Old Field
Nesting Habitat
FORAGING RANGE (Kilometres)
Foraging Habitat
Pre-*Vaccinium*
QUEENS
Vaccinium Bloom
QUEENS
Post-*Vaccinium*
WORKERS and REPRODUCTIVES
Forest Edge
Open Thicket
Forest Edge
Open Thicket
Blueberry Field
Open Thicket
Wild Flower
Bombus
COLONY LIFE SPAN APRIL -SEPTEMBER

Fig. 11. Seasonal patterns of habitat utilization by *Bombus* within the New Brunswick agro-ecosystem.

wide bee abundance at these sites made it more difficult to locate nests at these site, however, nesting tunnels of four of the same species that were found nesting in sandy-loam substrates in the south established nests in the sandier soils of the north. Although this indicates a certain amount of flexibility in the type of soil that can be utilized by an Andrenid species, the shallower nesting tunnels found in sandy soil indicate the less desirable nature of this substrate. As such, sandier soils must be considered as a potential limiting factor to *Andrena* populations.

If the underlying soil conditions are acceptable, the distribution of *Andrena* species depends on micro-environmental factors. All *Andrena* select nesting sites in areas of fields where the O_2 horizon was loose and pliable with low organic carbon content, often with a considerable amount of the leached A_2 layer visible at the surface (Schrader and LaBerge, 1976). Many species utilize the same type of soil, but select nesting sites based on the amount of vegetational cover. Five species (*A. regularis*, *A. vicina.*, *A. crataegi*, *A. bradleyi* and *A.* sp.3) nested within the blueberry fields among sparse to intermediate stem cover. Areas of sparse plant cover along the margins of the field were utilized as nesting sites by the aggregate nesting *A.* sp.1. The majority of *A. carlini* nest sites were located along dirt roadways crossing the blueberry fields. These sites were generally devoid of vegetation. *A. alleganiensis* was unlike all the other *Andrena* species in that it selected outwash areas of the blueberry field consisting of sand, pebbles and cobbles.

Undisturbed Woodland is the primary nesting habitat for *Bombus* with Open Thickets and Old Fields selected less frequently. Within these habitats, Bombus queens select abandoned rodent nests or cavities in or under decaying or fallen trees. The protection of such undisturbed habitats is critical in maintaining *Bombus* populations within the wild blueberry agro-ecosystem. Data indicates that agro-ecosystems that have greater than 40% undisturbed nesting habitat, along with sufficient seasonal forage, can accommodate a large *Bombus* population.

Both *Andrena* and *Bombus* are polylectic species and are thus able to exploit a wide variety of flowering plants for nectar and pollen. When both taxa area active in the environment at the same time (pre-*Vaccinium* and *Vaccinium* bloom) analysis of pollen loads indicate that they utilize the same forage species. However, when these taxa co-occur they display different spatial distributions among foraging-yielding habitats. During the pre-*Vaccinium* flowering period, the majority of flowering plants were found along Forest Edges or in Open Thickets. When floral abundance in each habitat was held constant, *Andrena* selected forage along the Forest Edge over forage in the Open Thickets. This, despite the fact that similar floral assemblages were found within each habitat. The most likely explanation for this behaviour is that the majority of bees emerging from overwintering nesting tunnels within the blueberry field would first encounter the Forest Edge when they began searching for food. As is common with many solitary bees, return visits are often made to floral sources that proved rewarding on previous foraging bouts (Cane and Payne, 1993). In contrast, the distribution of *Bombus* queens among habitats was proportional to floral availability.

During the *Vaccinium* flowering period, the Commercial Blueberry field was the primary foraging yielding habitat. Forest Edges and Open Thickets were also important foraging habitats. Although 49 to 74% of *Andrena* foraged on

Vaccinium, the percentage of selecting forage along the Forest Edge was higher than predicted based on floral availability at study sites. A combination of three factors could account for this foraging distribution. (1) Foraging patterns established prior to the blueberry bloom may continue to influence *Andrena* foraging behaviour even when *Vaccinium* is present within their foraging range. (2) Bees nesting within sprout portions of fields may continue to forage along Forest Edges because *Vaccinium* is beyond their foraging range. (3) *Andrena* may prefer flowering plant species found along the Forest Edge in favour of *Vaccinium*. From 58 to 68% of *Bombus* queens within study sites foraged at *Vaccinium*. As was the case during the pre-*Vaccinium* period, their distribution among forage-yielding habitats was proportional to floral availability. Interesting, only 48 to 55% of *A. mellifera* released at study sites foraged on the commercial blueberry field. This situation is clearly a result of bees being drawn off the crop in favour of co-flowering forage in other habitats. Alternative forage within wild blueberry agro-ecosystems creates a pollination paradox. On the one hand, this research demonstrates that systems with greater indigenous bee abundance in non-*Vaccinium* habitats tend to have higher indigenous bee foraging density on the crop. On the other hand, alternative forage during the *Vaccinium* bloom diminishes the pollination contribution of honey bees.

This study has established the interdependence of post-*Vaccinium* forage, mid-summer *Bombus* worker abundance and the population density of *Bombus* queens available for blueberry pollination in the following Spring. Given that appropriate nesting sites are available, systems with abundant bee forage (June-August) enable the development of larger colonies (more workers). This is characterised by higher numbers of mid summer *Bombus* workers within floral rich areas as opposed to those areas with lesser amounts of forage. Heinrich (1979) found that stronger colonies produced more reproductives (males and queens) than did smaller, weaker colonies. Here, mid-summer *Bombus* worker number (used as an indicator of site-wide colony strength) was positively correlated with the foraging density of *Bombus* queens on *Vaccinium* the following spring. This relationship highlights the direct importance post-*Vaccinium* forage on *Bombus* queen numbers and, by extension, blueberry pollination.

During the post-*Vaccinium* period, forage within wild blueberry agro-ecosystems is primarily associated with Wild Flower areas and Open Thickets. Combined these habitats housed from 82 to 99% of the available forage. Such habitats are not always present, and, when they are, the amount of floral resources contained with in them can be highly variable. Because of the important relationship these habitats have to blueberry pollination, great care should be taken when establishing new blueberry land or two rehabilitating existing systems to incorporate post-*Vaccinium* bee forage into the landscape mosaic. The extended flight range of *Bombus* workers allows access to floral resources at some distance from nesting sites. As such, floral resources at this time of year do not have to be evenly distributed throughout the entire system, as was the case during the pre-

Vaccinium period. Instead, floral enclaves can well removed from blueberry fields.

The size of post-*Vaccinium* floral enclaves (Wild Flower areas and Open Thickets) that should be set aside will depend greatly on the floral density within them. Large populations of *Bombus* workers were accommodated within study areas when seven percent or greater of the land area had moderate to high floral densities. Because foraging areas for bees at this time of the year can be somewhat removed from growing areas, the establishment and maintenance of floral assemblages will not conflict with weed management on blueberry fields. As such, major forage plants such as *Viccia cracca*, *Hypericum perforatum*, *Trifolium pratense*, *Trifolium repens*, *Medicago*, *Rubus*, *Rosa*, *Kalmia angustifolium*, *Solidago* and *Aster* can be encouraged without impacting blueberry production.

Foraging flight range must be a consideration when managing wild blueberry agro-ecosystems for *Andrena* species. Larger species examined in this study such as *A. carlini* and *A. regularis* demonstrated the ability to exploit floral resources located at considerable distances from their nesting sites. *A. carlini*, and *A. regularis* had maximal observed foraging flight ranges of 1,250 and 925 metres, respectively. The foraging flight range of small to mid-size *Andrena* is much more restricted. *A. alleghaniensis* (8mm) had a maximal foraging range of 410 metres whereas *A.* sp.1 was observed foraging no further than 675 metres from their nesting sites. From this data, we can assume that other members of the *Andrena* blueberry pollination complex, not studied here, will follow the general pattern of greater maximal foraging flight ranges with increased body size. Adequate forage for each *Andrena* species must be found within its respective foraging flight range. Larger *Andrena* are able to exploit a wider foraging radius as opposed to smaller species and are, therefore, less constrained by the distribution of floral resources within wild blueberry agro-ecosystems. Natal cell production did not significantly differ for *A. carlini* and *A. regularis* whether it established nests in the crop portion of the field or in the sprout portion of the field 800 to 900 metres away from the crop field. However, this situation affected natal cell production in *A*.sp1. This bee nested in large aggregation in bare patches along the margin of the blueberry field. During the pre-*Vaccinium* period bees nesting beside the crop and sprout portions of the field utilized similar forage abundance presented along the forest edge. Once *Vaccinium* started flowering bees nesting adjacent to the crop portion of the field had significantly higher floral availability than those nesting adjacent to the sprout portion of the blueberry field did. Unlike *A. carlini* and *A. regularis*, the restricted flight range of this species precluded those bees nesting adjacent to the sprout potion of the field from foraging in the commercial blueberry field. As a result of this, bees nesting adjacent the sprout field had significantly lower natal cell production than nesting by the crop field. Also of interest here, is that the maximal foraging flight distance of bees nesting adjacent the sprout field (410 metres) was greater than that of bees nesting by the crop field (200 metres). This indicates an increased search effort to locate forage.

The extended flight ranges of both *Bombus* queens and workers is well documented. They will travel several kilometres from nesting sites to exploit flower patches with high nectar and pollen rewards. As such, the distribution of floral resources within the wild-blueberry agro-ecosystem does not affect *Bombus* in the way it does many *Andrena* species. The only time that the spatial distribution of floral resources affects *Bombus* is when queens are searching for nesting sites, as they tend to establish nest sites close to forage. *Bombus* nest initiation takes place in early spring (late April to early June). At this time of the year forage availability is limited to Forest Edges, Open Thickets and, although not found in this study, bogs. Therefore, abundant, evenly distributed forage within these habitats is critical during this period.

Conclusions

In order to maintain or enhance indigenous bee populations a diverse landscape mosaic must be incorporated into wild blueberry agro-ecosystems. Areas of undisturbed woodland should be set aside as nesting refugia for *Bombus*. Similarly, management strategies for blueberry fields must take into account the preservation of nesting micro-environment for *Andrena*. To do this, the build up of organic matter in certain areas of fields should be managed so that *Andrena* have areas of unimpeded access to nesting substrate amongst the blueberry stems.

This study demonstrates the importance of Edge habitats as major foraging areas for indigenous bees prior to and during the *Vaccinium* bloom. Encouraging or transplanting important species such as *Salix* and *Amelanchier* at regular intervals along this habitat (including shelterbelts) will provide bees with critical early season forage. When developing new blueberry land, fields should be created with irregularly shaped borders to increase the surface area of edge habitat, thus increasing potential floral volume within the agro-ecosystem.

To promote the development of strong *Bombus* colonies, forage must be maintained within wild blueberry agro-ecosystems following the *Vaccinium* flowering period. Areas with higher mid summer floral abundance generally housed larger populations of *Bombus* workers. This research shows the strong interdependence between *Bombus* worker levels during the summer and the number of *Bombus* queens available for blueberry pollination the following spring. As such, the establishment of summer floral enclaves within blueberry growing areas is an essential step in enhancing the *Bombus* queens and, by extension, blueberry pollination.

This research has shown that the population levels of indigenous bees available for blueberry pollination are linked to the seasonal habitat attributes of the surrounding agro-ecosystem. Management of these systems in a manner that incorporates seasonal patterns of habitat utilization, as derived in this study, will promote the conservation and enhancement indigenous bee populations.

References

Edwards, M. 1996. Optimizing habitats for bees in the United Kingdom – a review of recent conservation action. In: The Conservation of Bees. Academic Press. London. Pp. 35-45.

Cane, J.H. and J.A. Payne. 1993. Regional, annual and seasonal variation in pollinator guilds: intrinsic traits of bees (Hymenoptera: Apoidea) underlie their patterns of abundance at *Vaccinium ashei* (Ericaceae). *Ecology and Population Biology*. **86**, no 5. 577-588.

Heinrich, B. 1976. Flowering phenologies: bog, woodland and disturbed habitats. Ecology **57**: 890-899.

Javorek S.K. and S.P. Vander Kloet. 1999. Comparative pollination effectiveness among apoidean visitors of lowbush blueberry (*Vaccinium angustifolium* Ait.). (In preparation).

Kevan P.G. and W.E. LaBerge. 1978. Demise and recovery of native pollinator populations through pesticide use and some economic implications. Proceedings of the IV International Symposium on Pollination. Maryland Agriculture Experimental Station. Miscellaneous Publications. **1**: 489-508.

O'Toole, C. 1993. Diversity of native bees and agro-ecosystems. In: Hymenoptera and Biodiversity. C.A.B. International. Wallingford. 169-196.

Schrader, M.N. and W.E. Laberge. 1978. The nest biology of the bees *Andrena* (Melandrena) *regularis* Malloch and *Andrena* (Melandrena) *carlini* Cockerell (Hymenoptera: Andrenidae). Illinois Natural History Survey. Biological Notes **108**: 1978.

Vander Kloet, S.P. 1983. The relationship between seed number and pollen viability in *Vaccinium corymbosum* L. HortScience **18**: 255-226

MAXIMIZING PHENOL YIELD FROM WILD BLUEBERRY FRUIT THROUGH FERMENTATION AND BIO-TRANSFORMATION

LA BIO-TRANSFORMATION DU BLEUET SAUVAGE AFIN DE MAXIMISER LA PRODUCTION DE PHÉNOLS

C. Matar[1], P. Roy[1], W. Kalt[2], R. Bernier[3] and/et J. Argall[3]

Partner / Partenaire: BioAtlantech Inc./ Vaccinium Technologies Inc.

Abstract: A number of experiments were conducted to determine the value of fermentation in enhancing flavonoid yields from post-processed wild blueberries. Naturally occuring microbes reveal some promise for enhancement of phenolics (of which flavonoids are a subset) through fermentation. The results also indicate that this phenomenon may not be consistent from one batch to another. In light of this, a screening of several hundred isolates may provide some leads for a more standard approach. Other possible mechanisms for consistently enhancing flavonoid yields are suggested, and these methods are presently the object of further study.

Résumé : Un certain nombre d'expériences ont été faites pour déterminer le rôle de la fermentation dans l'augmentation de la teneur en flavonoïdes des bleuets sauvages après transformation. Des microbes naturels semblent jouer un rôle dans l'augmentation de la teneur en phénole (dont les flavonoïdes constituent un sous-ensemble) lors de la fermentation. Les résultats indiquent aussi que ce phénomène varie d'un lot à l'autre. Par conséquent, l'examen de plusieurs centaines d'isolats pourrait mener à certaines pistes qui permettraient une approche plus uniformisée. D'autres méthodes proposées sont susceptibles d'augmenter de façon cohérente la teneur en flavonoïdes, et elles font actuellement l'objet d'études plus poussées.

Introduction

The production of value-added products derived from blueberries offers opportunity for continued growth of the New Brunswick wild blueberry industry. Wild blueberries are unique to the northeastern North American bio-region, and as such, offer some of the best growth opportunities for the region's agriculture. Members of the genus *Vaccinium* (Ericaceae) such as blueberry are rich sources of flavonoids (anthocyanins, flavonols, proanthocyanidins) (Macheix *et al.*, 1990).

Accumulated evidence from medical and nutrition research suggests that dietary flavonoids play a significant protective role against degenerative diseases such as heart disease (Hertog *et al., 1993)* and various types of cancer (Middleton, Kandaswami *et al.*, 1993). In addition to (or because of) their potent antioxidant activity, flavonoids are reported to be beneficial against allergies, inflammation, hepatotoxins, microbes, ulcers, viruses and tumors. As cardioprotective agents, flavonoids inhibit specific enzymes that contribute to elevated blood pressure, they strengthen the capillaries that carry oxygen and essential nutrients to cells, and they prevent the oxidation of low density lipoprotein. Anthocyanins and other related phenolic compounds are abundant in the North American wild blueberry fruits (Kalt *et al*, 1996).

---

[1] University of Moncton, NB, E1A 3E9 / Université de Moncton, Moncton, NB, E1A 3E9

[2] Agriculture and Agri-Food Canada, Horticulture Research Centre, Kentville, NS B4N 1J5 / Agriculture et Agroalimentaire Canada, Centre de recherche en horticulture, Kentville, N.-É. B4N 1J5

[3] BioAtlantech Inc., Fredericton, NB E3B 5A6

In this work, a novel approach will be applied to maximize extraction of the antioxidant flavonoids from wild blueberries. Fermentation has been used for grape juice and wine products in Ontario (Fuleki *et al*, 1974) and Europe (Mayén *et al.*, 1995), but has never been applied to *Vaccinium* berries like the wild blueberry. Fermentation of the skin of pomace samples from two grape cultivars doubled the recovery of total anthocyanins when compared to other pressing operations (Fuleki *et al.*, 1986). Immediate-press wines and juices had the lowest levels of all phenolics measured, while skin-fermentation wines had higher levels of all phenolics when compared to hot press wines or juices. Levels of epicatechin, catechin and ellagic acid have also been shown to increase during fermentation (Auw *et al.*, 1996). Fermentation might also increase the stability of anthocyanins and protect them from oxidation. Flavonoid contents of tea (flavone, catechin, and quercetin) were also increased during the fermentation process (Gorski *et al.*, 1996).

This project's primary goal was to stabilize or enhance flavonoid yields through fermentation of wild blueberries through two research objectives which were:

1. To identify the best microbial inoculum to maximize flavonoid yield or generate new moieties from wild blueberry through fermentation and bio-transformation processes;

2. Screening of natural isolates for their bio-transformation capabilities

Materials and Methods

Series 1 experiments: Naturally-occurring fermentation. As a precursor to more advanced trials, simple fermentation experiments were run with inoculation by microbial strains other than those naturally present on "post-processed" wild blueberries. These were reported in the 1999 interim report (Matar *et al.*, 1999). Other experiments were also conducted and will be discussed in the results section. The materials and methods for two experiments with similar methodology are reported here: (Series 1.1) pasteurized versus unpasteurized samples; and (Series 1.2) samples processed with and without the biocide sodium azide.

(a) **Preparation of the wild blueberry samples.** Wild blueberries harvested from various areas of the Atlantic region were mixed and frozen prior to use. The fermentation substrate consisted of frozen wild blueberries blended in a Braun Type 4259 food processor for a few minutes, then transferred into a 250-ml Erlenmeyer flask. A minimal growth Davis broth was added to the blueberry in a 1:1 ration. In Series 1.2 experiments, sodium azide at 0.05% was added to the blueberry mixture. The fermentation broth was then autoclaved for 15 minutes in an Amsco Century SV-116 Scientific Prevacuum Sterilizer.

(b) **Preparation of fermentation flasks and fermentation.** The flasks and the minimal broth were sterilized beforehand. In Series 1.1 experiments, the blueberry media was pasteurised at 65°C for 10 minutes. The goal of this procedure was to minimize the growth of unwanted microorganisms already present in the flasks. The treated and untreated blueberry media were incubated in a Tecator 1024 Shaking Water Bathwater at either 25°C or 30°C. Agitation was adjusted to an average speed of 70 RPM. Duration of the fermentation time varied from 3 to 5 days depending upon the experimental protocol established for each fermentation procedure.

(c) **Sampling.** Samples were taken at specified times during the experiments and stored in sterile centrifuge tubes. They were then frozen at -4°C until the end of the fermentation. During each sampling, the pH level was measured with a Hanna instruments HI 8424 pH-meter, and the total soluble solids were measured with a Atago Model N1 hand refractometer. A microbial count was performed. Colonies grown on Petri dishes were enumerated after 48 hours of incubation. After fermentation the collected samples were thawed, centrifuged at 1700 rpm for 6 minutes in an International Model HN centrifuge, and distributed in sterilized 4-ml amber glass sample vials.

(d) **Phenolics.** The fermentation broth samples were analysed for total phenolics using the standard spectrophotometric method adapted from the Folin-Ciocalteu Method for measurement of total phenolics. The quantity of sample and standard used during this analysis had been reduced from 200µL to 20µL in order to keep the results within the gallic acid calibration standards. Samples were placed in Fisherbrand polystyrene cuvets and read using a Beckman DU-65 spectrophotometer set at a wavelength of 640 nm.

(e) **Statistical analysis.** All reported data represents 3 samples, and 2 sub-samples, for a total of six measurements per treatment. T-tests were run comparing treatments, within a given time interval.

Series 2 experiments: Batch screening of several natural bacterial isolates for biotransformation. While only the experiments on naturally occuring microoganisms are presented from Series 1 trials, some simple inoculation trials were also conducted early in the research. These are reported in the interim report of 1999, and fermentation with these cultures decreased phenol yields (interim report, Matar *et al.*, 1999). With the longer-term goal of identifying microbes with superior fermentative transformation capacity, a broad-based screening of bacterial isolates for biotransformation of pure phenolic extracts is underway. (Series 2 experiments)

(a) **Isolation of naturally occuring microbes for screening.** A multitude of naturally-occuring bacteria were collected from eight woodland and marine locations in southeastern New Brunswick. In obtaining isolates from these collected materials, the following protocol was followed. The material was suspended in 100 mL peptonized water (pH 7) during 30 minutes at room temperature, then transferred in 1 mL aliquots to 10mL of peptonized water adjusted to each of the seven following pH levels: 3, 4, 5, 6, 7, 8, and 9; and to each of the two following salt levels: 0.5% NaCl and 5% NaCl. These in turn were heated to temperatures of 25°C, 35°C, 45°C and 55°C, with each ten-degree rise occuring at 30 minute intervals. At each temperature, samples were cultured on TSA medium and incubated for 3 days at 22°C. Distinct colonies were further isolated and cultured in test tubes, then incubated for one day. This resulted in the production of several hundred isolates, which were cold stored for several months for fermentation trials with pure phenolic extracts. Since the initial isolations, the cultures have been subcultured, and further stored in glycerol medium at -20°C.

(b) **Preparation of standarized pure phenolic extracts.** C-18 phenolic extracts were prepared using a standard procedure developed at AAFC Kentville. This involves: polyphenoic extraction of blueberry using optimal solvent systems based on polarity and solubility properties of phenolics, removal of solvents, separation of phenolics from other fruit components using a C-18 reverse phase chromotography column and standardization of extract. Standardized extract was freeze-dried prior to use in bio-transformations.

(c) **Bio-transformation of pure phenolic extracts with naturally occuring isolates.** Bio-transformation of the pure phenolic extracts was assayed with approximately five-hundred and fifty (550) individual microbial isolutes as per section (a). One mL of the culture TS broth was centrifuged at 14,000 rpm for ten minutes. These were separated into cell-free supernatant (i.e., to evaluate extra-cellular enzymes and products) and cell suspension (i.e., bacterial cells). 15 μL of each of these was combined with 285 μL of the pure phenolic extract in acetate buffer (pH = 4, 18°C) with yeast extract. All strains were tested at 20°C, for each of three and twenty-four hours. The bio-transformations were arrested by exposure to -20°C for several days, prior to lyophilisation before being returned to AAFC, Kentville for antioxidant (oxygen radical absorbing capacity, ORAC) testing. This process is represented diagramatically in Figure 1.

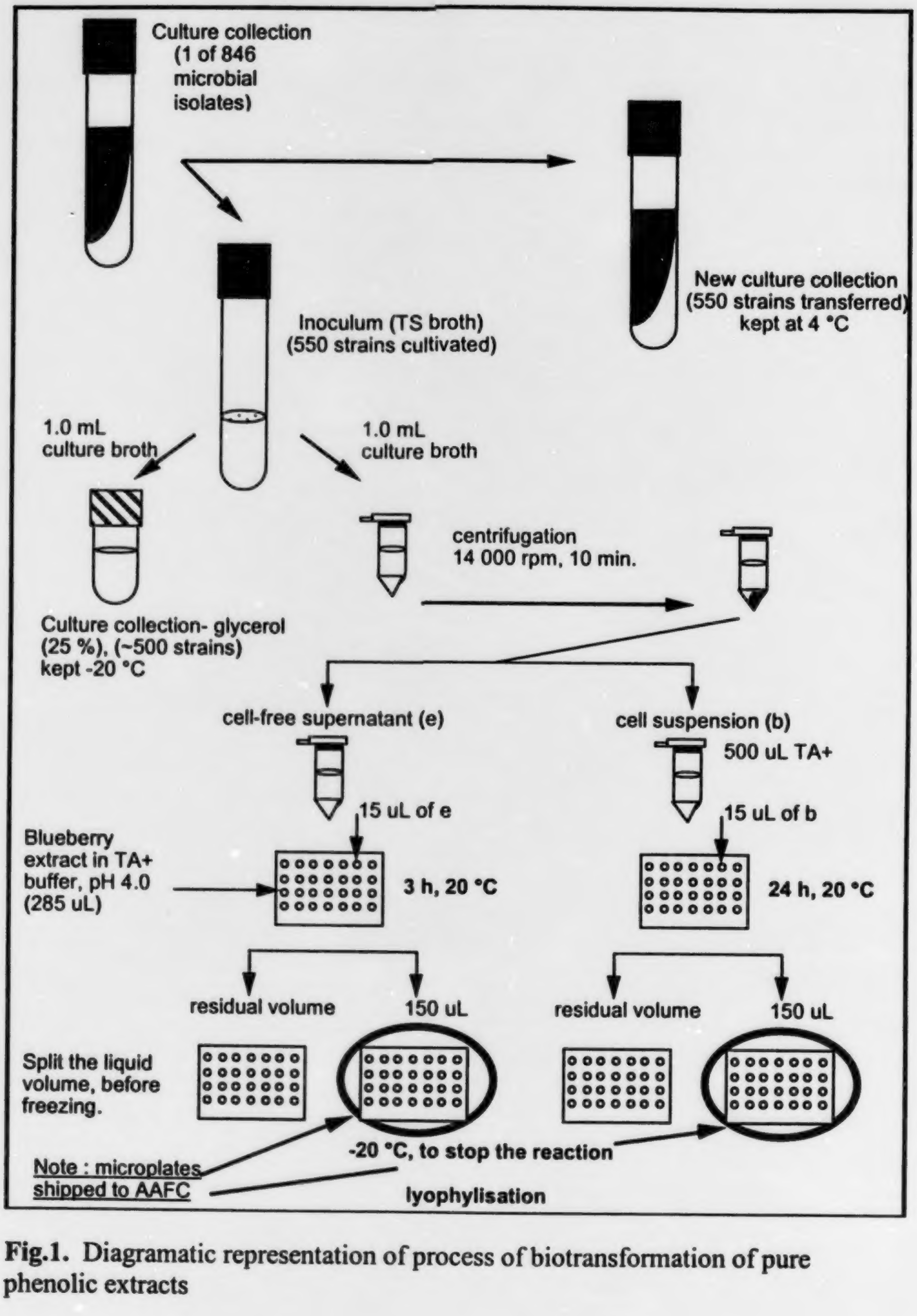

Culture collection (1 of 846 microbial isolates)
New culture collection (550 strains transferred) kept at 4 °C
Inoculum (TS broth) (550 strains cultivated)
1.0 mL culture broth
1.0 mL culture broth
centrifugation 14 000 rpm, 10 min.
Culture collection- glycerol (25 %), (~500 strains) kept -20 °C
cell-free supernatant (e)
cell suspension (b)
500 uL TA+
15 uL of e
15 uL of b
Blueberry extract in TA+ buffer, pH 4.0 (285 uL)
3 h, 20 °C
24 h, 20 °C
residual volume
150 uL
residual volume
150 uL
Split the liquid volume, before freezing.
-20 °C, to stop the reaction
Note : microplates shipped to AAFC
lyophylisation

Fig.1. Diagramatic representation of process of biotransformation of pure phenolic extracts

Results and Discussion

Series 1 Experiments: Trials on bio-transformation by resident microflora. Different fermentation conditions were tested during the preliminary phase of this study, including different pasteurization times, microbial strains, sources of wild blueberries, concentration of inoculum, nutritive ingredients and media. Some of these results were presented in the interim report in 1999. These preliminary experiments helped to define optimal conditions, and the experiments reported here will serve to reflect certain trends which were encountered.

Figure 2 presents results from trials which began on May 30, 1999 on pasteurized and unpasteurized samples of wild blueberry/Davis broth mixtures. Though there is no significant statistical difference between the level of phenolics prior to pasteurization (day 0), the levels increase dramatically over the three sampling days for the unpasteurized samples, while they decrease for the pasteurized samples. By day 3, the phenolics in the unpasteurized samples were four times greater than the unpasteurized. Within the unpasteurized samples, these levels at day 3 are 2.5 times greater than they were at day O. The results also suggest that phenolics are adversely affected by pasteurization. The results lend support to the hypothesis that microbes naturally present on the wild blueberry could work to augment phenolic levels during fermentation, since pasteurization would have been expected to kill most microorganisms, save the thermophilic and sporulating blueberry ones.

This hypothesis appears to be further confirmed by the results of a trial which began on October 14, 1999, in which the wild blueberries were treated with sodium azide, a non-selective microbial biocide. These results are reported in Figure 3. In this instance, the phenolic levels remained fairly stable over a 5 day fermentation period in samples treated with sodium azide, while these levels increased four-fold by day two in untreated samples. Beyond day two, the increase was maintained at a relatively stable, high level.

t-test significance:
- * significant
- ** very significant
- *** highly significant

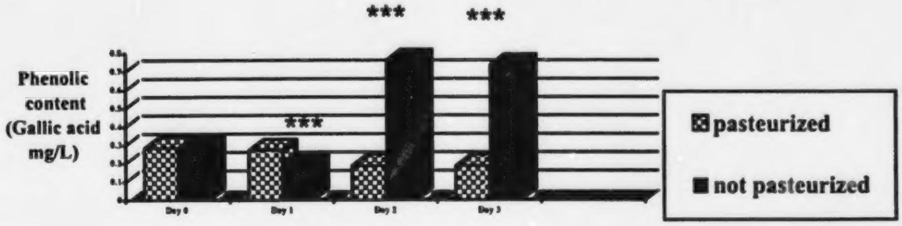


Fig. 2. Levels of phenolics at several intervals for pasteurized and unpasteurized fermenting samples of wild blueberries plus Davis broth (1:1 v/v) held at 25°C (3 samples x 2 sub-samples)

t-test significance:
- * significant
- ** very significant
- *** highly significant

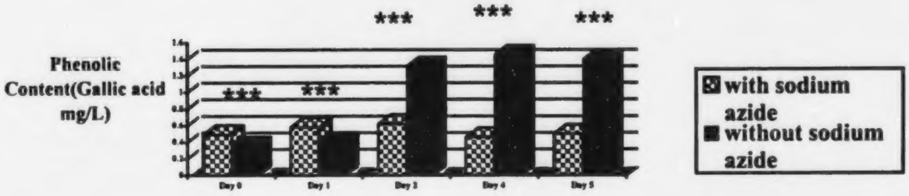


Fig. 3. Levels of phenolics at several intervals for fermenting samples of wild blueberries plus Davis broth (1:1 v/v), with and without 0.05% sodium azide at 30°C (3 samples x 2 sub-samples)

Conclusions

Fruits such as wild blueberry provide a natural habitat for yeasts, lactic acid bacteria and other food-grade microorganisms. These heterogenous populations may reflect a natural association of several bacteria, yeast or even mould strains, often including several species or genera. The bacteria resident on such fruit would be expected to be adapted to the conditions found on the fruit's surface. It is possible that resident bacteria, perhaps acting in symbiosis, are capable of extracting nutrients in the fruit and generating higher levels of phenolics. This would be consistent with findings for grapes (Fuleki *et al.*, 1986; Auw *et al.*, 1996) and tea (Gorski *et al.*, 1996).

Additional trials to those reported here were conducted. Trials with resident microflora have in fact had variable results, implying that the composition of this microflora is not necessarily consistent from one batch to another. Similarly, preliminary trials using inoculation by two batch cultures of microorganisms was reported in the 1999 interim report. In these instances, inoculation decreased phenolic yields relative to samples that were not inoculated.

In this second year of study, with a "proof of concept" regarding enhanced polyphenolic levels of blueberry fermentation in year 1 an extensive screening of newly isolated microorganisms for their potential to enhance phenolic yields from wild blueberries is underway. The measurement of these phenolic yields is still taking place, and may identify isolates that are capable of bio-transforming in ways that are favorable to a controlled process of phenolic enhancement, through either greater consistency and/or effectiveness than the resident microflora. The combination of the novel isolate, fermentation conditions and bio-transforming of blueberry phenolics may constitute new discoveries.

Two avenues of future research have been opened up by the work so far, and are presently being conducted:

1. **Enhancement of phenolic yield and stability through fermentation by the resident microflora**. A post-graduate student at Université de Moncton continues work on optimizing fermentation conditions of pH and temperature. Additional work on identification of superior "resident" strains also remains a priority, and is warranted since these organisms may be optimally suited for metabolism of blueberry fruit components.

2. **Enhancement of phenolic yield through fermentation by inoculation with novel microbial isolates**. Completion of work on isolate screening, with the goal of identifiying strains with predictable impacts on phenolic yields, could be of value in identifying strains capable of biotransformation of endogenous phenolics to yield new moreties with potential utility which would be more amenable to standardized, industrial-scale operations.

Both avenues will benefit from additional HPLC work on determination of levels of important flavonoids.

Acknowledgments

Additional financial support for this project was provided by the NB Agriculture Council (Project # NBAC-34-98).

References

Auw, J.M., V. Blanco, S.F. O'Keefe and C.A. Sims. 1996. Effect of processing on the phenolics and color of Cabernet Sauvignon, Chambourcin, and Noble wines and juices. *American Journal of Enology and viticulture*, **47**: 279-286

Bloch, A., A.T. Cynthia. 1997. Position of the American Dietetic Association : Phytochemicals and functional foods. *Journal of Nutraceuticals, Functional & Medical Foods,* **1 (1)**: 33-45

Bomser, J., D.L. Madhavi, K. Singletary, and M.A.L. Smith. 1996. In vitro anticancer activity of fruit extracts from *Vaccinium* species. *Planta Medica* **62**: 212-216

Fuleki, T. 1974. Application of carbonic maceration to change the bouquet and flavor characteristics of red table wine made from Concord grapes. *Institute of Food Science and Technology Journal*, **7 (4)**: 269-273

Fuleki, T. and L. Babjak. 1986. Natural food colourants from Ontario grapes. *Highlights,* **9**: 6-9

Gorski, K.M. and G.E. Barringer. 1996. Flavonoids in beverages: photodiode array spectroscopic detection for chromatographic assays. *American Laboratory*, **28**: 98-99

Hertog, MGL, E.J.M. Feskens, P.C.H. Hollman, M.B. Katan, D. Kromhout. 1993. Dietary antioxidant flavonoids and risk of coronary heart disease: the Zutphen Elderly Study. *The Lancet,* 342: 1007-1011

Kalt, W. and J.E. McDonald. 1996. Chemical composition of lowbush blueberry cultivars. *Journal of the American Society for Horticultural Science*, **121**: 142-146.

Mayén, M., J. Mérida, and M. Medina. 1995. Flavonoid and non-flavonoid compounds during fermentation and post-fermentation standing of musts from Cabernet Sauvignon and Tempranillo grapes. *American Journal of Enology and Viticulture*, **46 (2)**: 255-261

Macheix, J-J, A. Fleuriet and J. Billot 1990. *Fruit Phenolics*

Matar, C., P. Roy, W. Kalt and R. Bernier. 1999. Interim SPDF report. Maximizing Phenolics Yield from Wild Blueberry Fruit by Fermentation

Middleton, EJr, and Kandaswami, C. 1993. The impact of plant flavonoids for mammalian biology: implications for immunity, inflammation and cancer (Chapter 15). Harborne, JB, Editor. *The Flavonoids: Advances in Research Since 1986.* London: Chapman & Hall; 619-652

Tharuk, B.R. and S.S. Arya. 1989. Studies on stability of blue grape anthocyanins.*International Journal of Food Science and Technology*, **24:** 321-326

EVALUATION OF CASORON 4G FOR USE ON SANDED AND NON-SANDED CRANBERRY BEDS

ÉVALUATION DU CASORON 4G DANS DES PARCELLES DE CANNEBERGE SABLÉES ET NON SABLÉES

K.V. McCully[1], V. Little,[2] Boyd Peters[2] and/et N. Pothier[1]

Abstract : Three trials (2 small plot, 1 fields scale) were established to evaluate the effect of applying Casoron 4G to both sanded and non sanded cranberry beds. Visual ratings on crop injury and weed control were collected throughout the summer on the two small plot research trials. Cranberry yields were collected from all trials. In the small plot research trial on sanded beds, Casoron was evaluated at 26, 58, and 90 kg/ha respectively. Results indicated that Casoron rates above 26 kg/ha caused significantly higher visual crop injury throughout the season. Although yields were reduced from the higher Casoron rates, differences were not considered significant. On the larger field scale trial Casoron applied at 56 kg/ha out yielded the 26 kg/ha rate when applied on sanded beds, but differences were not considered statistically different. No differences were noted between any of the Casoron rates and level of weed control. There did not appear to be any significant benefit in applying Casoron rates above 26 kg/ha on sanded beds at this site. In the small plot research trials conducted on non-sanded beds, Casoron was evaluated at 51.6, 83.6, and 115.6 kg/ha respectively. Results indicated that Casoron rates applied above 51.6 kg/ha caused significantly higher visual crop injury throughout the season. Yields from Casoron applied at 51.6 kg/ha (22.2 barrels/acre) and 83.6 kg/ha (22.5 barrels/acre) were almost identical. Yields were reduced as the rate increased to 115.6 kg/ha (13.1 barrels/acre), however. On the larger field scale trial (non-sanded beds) the 56 kg/ha Casoron rate (33.6 barrels/acre) out yielded the 84 kg/ha Casoron rate (27.7 barrels/acre), but differences were not significant. No differences were noted between any of the Casoron rates and the level of weed control. There did not appear to be any significant benefit to applying Casoron above 51.6 kg/ha on non-sanded beds at this site.

Résumé : Trois essais ont permis d'évaluer l'effet du Casoron 4G appliqué dans des parcelles de canneberge sablées et non sablées. Deux des essais ont eu lieu dans de petites parcelles, et l'autre en plein champ. On a fait une évaluation visuelle de l'endommagement de la culture et vérifié le taux de destruction des mauvaises herbes tout au long de l'été dans les petites parcelles. Des données sur le rendement des canneberges ont été recueillies dans tous les essais. On a évalué l'effet d'applications de 26, 58 et 90 kg/ha respectivement dans les trois essais sur parcelles sablées. Les résultats indiquent que les applications de Casoron supérieures à 26 kg/ha ont causé des dommages beaucoup plus élevés tout au long de la saison d'après l'évaluation visuelle. Les taux élevés de Casoron ont diminué les rendements, mais les écarts n'étaient pas jugés importants. Dans l'essai en plein champ, le rendement obtenu avec une application de 56 kg/ha de Casoron était supérieur à celui obtenu avec 26 kg/ha sur sol sablé, mais la différence statistique n'était pas jugée importante. On n'a pas relevé de différence dans le taux de destruction des mauvaises herbes entre les trois taux d'application. Les résultats indiquent qu'il ne semble pas très avantageux d'appliquer le Casoron à un taux supérieur à 26 kg/ha. Dans les cannebergières sablées, on recommande aux producteurs d'appliquer environ 26 kg/ha de Casoron pour se familiariser avec l'utilisation de ce produit. On pourrait envisager des taux supérieurs à l'avenir s'il y a lieu. Dans les essais sur petites parcelles non sablées, l'évaluation a porté sur des applications de 51,6, 83,6 et 115,6 kg/ha respectivement. Les résultats indiquent que les applications de Casoron supérieures à 51,6 kg/ha ont causé beaucoup plus le dommage à la culture tout au long de la saison d'après l'évaluation visuelle. Le rendement à la suite d'une application de 51,6 kg/ha (22,2 barils l'acre) et de 83,6 kg/ha (22,5 barils l'acre) était presque identique, mais le rendement était plus bas à la suite d'une application de 115,6 kg/ha (13,1 barils l'acre). Dans l'essai en plein champ sur sol non sablé, le rendement avec une application de 56 kg/ha (33,6 barils l'acre) dépassait celui obtenu avec l'application de 84 kg/ha (27,7 barils l'acre), mais l'écart n'était pas important. On n'a pas relevé d'écart dans le taux de destruction des mauvaises herbes entre les trois doses de Casoron. Il ne semble pas avantageux d'appliquer des doses de Casoron supérieures à 51,6 kg/ha sur le sol non sablé à cet endroit. Dans les cannebergières non sablées, on recommande aux producteurs d'appliquer environ 51,6 kg/ha de Casoron pour se familiariser avec l'utilisation de ce produit. On pourrait envisager des taux supérieurs à l'avenir s'il y a lieu.

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1/ Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

[2] River Valley Cranberry Company Inc., P.O. Box 565, Fredericton, NB E3B 5A6

Introduction

One of the biggest challenges facing cranberry growers is weed control. Weeds compete with cranberry plants for moisture, nutrients, light and space. In addition weeds can also cause reductions in yield and quality, interfere with harvesting, and reduce stand longevity.

Weeds present within cranberry beds are diverse and tend to be different than weeds found in other crops. Herbicide selection is limited and weed control often inconsistent. The main two herbicides used for residual weed control within cranberry operations are Casoron 4G and Devrinol 10G. Devrinol is used mostly in the cranberry establishment years and Casoron after the second year. Recommendations on the use of these products vary between Canada and the United States, and even between individual States.

Sanding is a common practice associated with cranberry production. It is applied during the winter or early spring once every 2 to 5 years, to cover basal wood, anchor runners, encourage initiation of new roots, and to promote the production of uprights. The effect of sand on Casoron activity in relation to weed control and cranberry tolerance is not fully understood. It is generally thought that sanding may make the cranberry plants more sensitive and susceptible to Casoron injury. As a result, if sanding occurred it is often suggested that Casoron not be used at all, or to use only low rates.

Confusion exists as to proper rates and the effect of sanding on Casoron activity and crop tolerance. Two small plot research trials and a field scale trial were therefore established to evaluate various Casoron rates applied to both sanded and non-sanded beds.

Materials and Methods

Three trials were conducted. Two of the trials were small plot research trials and the other a large scale field experiment. The two small plot research trials were established in two different cranberry beds (winter sanded and non-sanded) in Maugerville, Sunbury County. Beds were planted during the summer of 1996. The soil was a loamy sand with a sand/silt/clay ratio of 81/14/5 for the sanded trial, and a sandy loam with a sand/silt/clay ratio of 74/18/8 for the non-sanded trial. The organic matter content was 0.6% for both trials. The soil pH in the sanded trial was 5.2 and 5.3 in the non-sanded trial. In both trials 4 treatments were arranged in a randomized complete block design with 4 replicates. Plots were 11 x 4 m in size, with an actual treated area of 11 x 3.66 m.

The grower applied 26 kg/ha of Casoron uniformly to all the sanded beds and 51.6 kg/ha of Casoron to all the non-sanded beds 9 days before treatments were applied to the small plots. Small plot rates reported are therefore the original application rate, as applied by the grower, topped up to the targeted rate 9 days later by the researchers. No untreated control plots were therefore possible to include. The top up herbicide applications were applied on May 21 with a push broadcast spreader and watered in later the same day. Cranberry plants had an average of 2.5 cm (range 1.25 to 4.0 cm) of new growth present at application.

Crop injury and weed control ratings were collected on June 30, August 6 and September 28. Ratings were collected on a scale of 0-100, where 0 represented no control or injury, and 100 represented a complete kill. Cranberries were hand-harvested on September 27. A 1 x 1 m^2 quadrant was thrown at random three times within each plot and total weights were recorded. Data was subjected to an analysis of variance and means separated by the LSD (Least Significant Difference) Test (P=0.05). Bartlett's Test was used to determine homogeneity of variances.

In the field scale trial, treatments were applied by the grower with a large boom granular applicator. The trial was spread over four different beds located at the same site as discussed above. Six treatments were evaluated: Casoron 28 kg/ha (sanded); Casoron 56 kg/ha (sanded); Casoron 56 kg/ha (non-sanded); Casoron 84 kg/ha (non-sanded); Casoron 28 kg/ha + Devrinol 49 kg/ha (sanded) and Casoron 28 kg/ha + Devrinol 49 kg/ha (non-sanded). Casoron treatments were applied May 12 and sequential Devrinol treatments were applied May 27. Treatments were watered in immediately.

Cranberries were hand harvested between September 28 and September 30 1999, by randomly throwing a $1m^2$ twelve times within each treated area of the bed. Data was subjected to an analysis of variance and means separated using LSD (Least Significant Difference Test) (P=0.05).

Results and Discussion

Trial 1. Evaluation of Casoron Applied to Sanded Cranberry Beds: Cranberry injury. Ratings collected on all dates indicated that the higher the Casoron rate, the higher the degree of visible injury. June 30 ratings (40 days after treatment-DAT) indicated that cranberries were very tolerant to the low rate of Casoron (26 kg/ha) whether applied alone (1.0%), or topped up with 44 kg/ha Devrinol (0%) (Table 1). The higher Casoron rates of 58 and 90 kg/ha resulted in 11% and 30% injury respectively (see Table 1). Injury was in the form of stunting and reddening of the cranberry leaves.

On August 6 (77 DAT), only the 58 kg/ha (21%) and 90 kg/ha (24%) Casoron rates resulted in unacceptable cranberry injury levels (Table 1). Cranberry plant uprights tended to be shorter, and all cranberry leaves were redder than observed at the lower rates. Although shorter and redder, there still appeared to be lots of developing fruit in these plots.

Table 1. Percentage of cranberry injury, percentage of weed control and yield data following herbicide applications on sanded cranberry beds

Treatment	Product Rate	% Cranberry injury (0-100)			% Overall weed control		Yields
		June 30	Aug. 6	Sept. 28	Aug. 6	Sept. 28	Barrels/ Acre
Casoron 4G	26 kg/ha	1.0	1.0	1.0	44	70	34.2
Casoron 4G	58 kg/ha	11	21	7.0	30	64	26
Casoron 4G	90 kg/ha	30	24	9.0	58	73	22.6
Casoron 4G + Devrinol 10G	26 kg/ha + 44 kg/ha	0	0	2.0	45	69	30.8
	LSD* 5%	4	2.5	3	12.7	7.9	N.S[(1)]

*Least significant difference

[(1)] Not significant

By September 28 (130 DAT), the difference between treatments was less obvious, as the reddening within plots disappeared. Cranberry plants were very tolerant to Casoron (26 kg/ha) (1.0%), and Casoron (26 kg/ha) + Devrinol (44 kg/ha) (2.0%) (Table 1). Visible injury from Casoron applied at 58 and 90 kg/ha was 7.0% and 9.0% respectively (Table 1). Injury observed at this time was in the form of height reduction (stunting).

Overall, results indicated that Casoron applied at 26 kg/ha either alone, or in sequence with Devrinol (44 kg/ha) to winter sanded beds should cause no significant visual crop injury throughout the season. The higher rates resulted in high initial injury levels but tended to recover to acceptable levels as the season progressed.

Percent overall weed control. Percent overall weed control ratings were collected, as individual weed species densities and distributions were not consistent enough from plot to plot or replicate to replicate to rate. Without the benefit of an untreated check plot it was also difficult to determine which weeds may have been controlled. The main weeds present in plots however included willow, rice cut grass, horsetail, golden rod, and smoke grass.

Results from the August 6 rating indicated that % overall weed control was poor from all the evaluated treatments, as control ranged from only 30 to 58% (Table 1). Reasons why Casoron applied at 58 kg/ha (30%) resulted in lower % overall weed control than the lower 26 kg/ha (44 %) is not understood. The highest % overall weed control resulted from the highest Casoron rate (90 kg/ha) (58%), but was still considered low.

By the final September 28 rating, % overall weed control was still considered lower than desired. Control ratings at this time ranged from 64 to 73% (Table 1). Casoron applications made at the lower 26 kg/ha applied either alone (70%), or with Devrinol (69%) were not significantly different from the higher Casoron 90 kg/ha rate (73%) (Table 1). The additional costs associated with applying higher rates of Casoron for weed control were therefore not justified at this site.

Yields. Although yields varied from a low of 22.6 barrels/acre to a high of 34.2 barrels per acre, differences between treatments were not considered statistically different. Trends were obvious however, as the higher the Casoron rate, the lower the yields. Casoron applied at 26 kg/ha resulted in 34.2 barrels/acre, followed by Casoron + Devrinol (26 kg/ha + 44 kg/ha) with 30.8 barrels/acre, Casoron 58 kg/ha with 26 barrels/acre, and Casoron 90 kg/ha with 22.6 barrels/acre (Table 1). It appears that there was no advantage in applying more than 26 kg/ha of Casoron, or in adding Devrinol to Casoron in this trial.

Trial 2. Evaluation of Casoron Applied to Non-sanded Cranberry Beds: Crop injury. Higher Casoron rates were evaluated in this trial as non-sanded cranberry plants are more tolerant to Casoron. Casoron rates evaluated ranged from 51.6 kg/ha to 115.6 kg/ha. The registered labeled rate for Casoron is 110 kg/ha.

Ratings collected at all dates indicated that the higher the Casoron rate, the higher the degree of visible injury. June 30 ratings (40 days after treatment DAT) indicated that only slight injury was observed from Casoron 51.6 kg/ha (7.0%), and Casoron + Devrinol 51.6 + 36.4 kg/ha (5.0 %) (Table 2). The higher Casoron rates of 83.6 kg/ha and 115.6 kg/ha resulted in 18% and 30% injury respectively (Table 2). Injury was in the form of reddening of the leaves and stunting of the uprights.

By August 6 (77 DAT), the only treatments displaying injury symptoms were the higher Casoron rates. Casoron applied at 83.6 kg/ha resulted in 10% crop injury and Casoron applied at 115.6 kg/ha resulted in 14% crop injury (Table 2). Although plants appeared shorter and redder, there still appeared to be lots of fruit developing in these plots.

By September 28 (130 DAT), the differences between treatments were less obvious, as reddening within plots had disappeared. Cranberries were visually very tolerant to Casoron applied at 51.6 kg/ha whether applied alone (2.0%), or applied sequentially with Devrinol 10G (2.0%) (Table 2). Cranberry visual injury this time. Injury was in the form of a slight reduction in height.

Percent overall weed control. Percent overall weed control ratings were collected, as individual weed species densities and distributions were not consistent enough from plot to plot or replicate to replicate to rate. Without the

Table 2. Percentage of cranberry injury, percentage of weed control and yield data following herbicide applications on non-sanded cranberry beds

Treatment	Product Rate	% Cranberry injury (0-100)			% Overall weed control		Yields
		June 30	Aug 6	Sept. 28	Aug. 6	Sept. 28	Barrels/ acre
Casoron 4G	51.6kg/ha	7.0	0	2.0	42	69	22.2
Casoron 4G	83.6 kg/ha	18	10	6.0	55	68	22.5
Casoron 4G	115.6 kg/ha	30.0	14	6.0	54	73	13.1
Casoron 4G + Devrinol 10G	51.6 kg/ha + 36.4 kg/ha	5.0	0	2.0	35	61	30.1
	LSD* 5%	12	4.6	2.9	N.S. (1)	7.2	13

*Least significant difference
(1) Not significant

benefit of an untreated check plot it was also difficult to determine which weeds may have been controlled. The main weeds present in the trial area however, included quackgrass, willows, ditch stonecrop, and some native grasses.

Results from the August 6 rating indicated that % overall weed control was poor from all the evaluated treatments. Control ranged from only 35 to 55%, and were not statistically different from each other (Table 2). Whether Casoron was applied at 83.6 kg/ha (55%) or 115.6 kg/ha (54%) the level of weed control was not influenced (Table 2).

By the final September 28 rating, % overall weed control was still considered lower than desired. Control ratings at this time ranged from 61 to 73% (Table2). Casoron applied at the 51.6 kg/ha rate alone resulted in 69% control, and was not significantly different from Casoron applied at 83.6 kg/ha (68%), or Casoron applied at 115.6 kg/ha (73.0%). From a weed control perspective, there did not appear to be any advantage in applying more than 51.6 kg/ha of Casoron, or applying Devrinol sequentially at this trial site.

Yields. Yields ranged from a low of 13.1 barrels/acre to a high of 30.1 barrels/acre (Table 2). Differences between Casoron 51.6 kg/ha (22.2 barrels/acre) and Casoron 83.6 kg/ha (22.5 barrels/acre) were minor and considered equal. The highest Casoron rate of 115.6 kg/ha however resulted in a yield reduction to 13.1 barrels/acre, but was not significantly lower than the Casoron 51.6 and 83.6 kg/ha rates. The highest yielding treatment resulted from Casoron 51.6 kg/ha +

Devrinol 10G 36.4 kg/ha applied sequentially (30.1 barrels/acre). Reasons why yields were higher from this treatment versus Casoron applied alone at 51.6 kg/ha is surprising as crop tolerance and weed control ratings for the two were very similar.

Trial 3. Field Scale Grower Trial. Although yields from the various treatments varied from 23.8 to 33.6 barrels/acre, statistical analysis indicated that differences were not considered significant (Table 3). Variations in crop stand and yields throughout the harvested areas were highly variable, and as a result made it more difficult to detect statistical differences. Some trends were evident however, and will be discussed.

Casoron was applied at 56 kg/ha to both a non-sanded bed and a sanded bed to determine the importance and effect of sanding at field scale. Results indicated that yield differences were only slight. Yields from the sanded beds were 34.4 barrels/acre, and yields from the non-sanded beds were 33.6 barrels/acre (Table 3). Sanding therefore did not result in reduced yields when Casoron was applied at 56 kg/ha.

In another comparison, Casoron was applied at 28 kg/ha and 56 kg/ha within the same beds to evaluate the influence of rates on beds which had been sanded. Yield results indicated that the Casoron 56 kg/ha rate resulted in a higher yield (34.4 barrels/acre) than the 28 kg/ha rate (27.8 barrels/acre) (Table 3). Yields were therefore not negatively impacted by increasing the Casoron rate from 28 to 56 kg/ha on sanded beds. Visual differences were however noted in plant growth. The higher Casoron rate resulted in redder and shorter growth.

In another comparison, Casoron was applied at 56 kg/ha and 84 kg/ha within the same beds to evaluate the influence of rates on non-sanded beds. Results indicated that Casoron applied at 56 kg/ha (33.6 barrels/acre) resulted in higher yields than when applied at 84 kg/ha (27.7 barrels/acre). The higher rate therefore reduced yields, but not significantly.

In another comparison, Casoron was applied at 28 kg/ha followed by Devrinol at 45 kg/ha to both sanded and non-sanded cranberry beds. Results indicated that the applications to the sanded beds resulted in a yield decrease. Yields from the sanded beds were 23.8 barrels/acre as compared to the non-sanded which yielded 31.4 barrels/acre. The difference was more than expected as small plot research did not indicate a difference. One part of the sanded bed where yields were collected, yielded poorly as the result of other factors not associated with herbicide. If this part of the bed had yielded like the rest of the bed, yields would have been very similar. It was felt that applications made to a more uniform bed would not have indicated as large a difference.

Table 3. Evaluation of cranberry yields following various Casoron and Devrinol applications to both sanded and non-sanded beds

Treatment	Product Rate	Sanded/ non-sanded	Bed Number	Yields Barrels/Acre
Casoron 4G	56 kg/ha	Non-sanded	6	33.6
Casoron 4G	84 kg/ha	Non-sanded	6	27.7
Casoron 4G Devrinol 10G	28 kg/ha; 49 kg/ha	Non-sanded	7	31.4
Casoron 4G	28 kg/ha	Sanded	14	27.8
Casoron 4G	56 kg/ha	Sanded	14	34.4
Casoron 4G Devrinol 10G	28 kg/ha; 49 kg/ha	Sanded	20	23.8
				Not Significant

Conclusions

Results from the trial evaluating Casoron applications on sanded cranberry beds (Trial 1) indicated that Casoron applied at 26 kg/ha could be applied safely. Rates above 26 kg/ha resulted in significantly higher visual crop injury. Yield reductions also resulted but were not significant. Weed control from Casoron applied at 26 kg/ha was also as effective as the higher rates evaluated. If this site had different, more susceptible weed populations, rates may have been more important. There did not appear to be any benefit in adding Devrinol to the lowest Casoron rate from a weed control perspective. Additional trials with untreated controls included should be conducted before confident recommendations could be made. Growers should start experimenting with Casoron rates around 26 kg/ha rate on sanded beds and gradually try increasing rates depending upon crop tolerance, weed species presence, weed density, weed distribution, and weed susceptibility in future years.

Results from the trial evaluating Casoron applications to non-sanded beds (Trial 2) indicated that cranberries were visually most tolerant to the lowest Casoron rate (51.6 kg/ha) whether applied alone or applied sequentially with Devrinol. The Casoron 83.6 kg/ha and 115.6 kg/ha rates displayed injury symptoms in the form of reddening and stunting until late in the season, at which time they recovered to injury levels of 6.0%. Early season injury (June 30) was high however, with 18 and 30% injury being reported from Casoron 83.6 kg/ha and 115.6 kg/ha respectively.

Yield data from the non sanded trial indicated that the highest yielding treatment was Casoron + Devrinol (51.6 + 36.4 kg/ha) (30.1 barrels/acre). The fact that this treatment out yielded Casoron applied at 51.6 kg/ha alone (20.7 barrels/acre) was surprising as no advantage was observed when crop injury or weed control was evaluated. Yields from plots treated with Casoron at 51.6 kg/ha and 83.6 kg/ha were almost identical and not significantly different from each other. Casoron applied at 115.6 kg/ha was higher than necessary, as yields were significantly reduced. Weed control ratings indicated that there was no benefit in applying Casoron above 51.6 kg/ha, or by adding Devrinol sequentially after Casoron application.

Before conclusive recommendations can be made it would be important to conduct additional trials with untreated controls included. Growers should experiment with Casoron rates around 51.6 kg/ha on non-sanded beds and gradually try increasing rates in future years depending upon crop injury observed, and weed species presence, density, distribution, and susceptibility.

Yield results from the large scale field trial indicated that Casoron could be applied safely to cranberry beds that had been sanded or not sanded at 56 kg/ha. As rates increased to 84 kg/ha on non sanded beds, yields were reduced, but not significantly. Casoron applied at 28 kg/ha was also applied and followed by a sequential treatment of Devrinol at 49 kg/ha on both sanded and non-sanded beds. Results indicated that yields were surprisingly reduced in the sanded beds. This conflicted the data collected in the small plot research, and is most likley related to yields being collected in a poor part of the bed.

Acknowledgements

Appreciation is extended to River Valley Cranberry Company for providing the trial site and for their cooperation and support during the trial. Appreciation is also extended to Dave Bell (UAP), Greg Sweetland (NBDARD), and Dan Ward (NBDARD) for their assistance with the trial.

TREE FRUIT / D'ARBRES FRUITIERS

A DEMONSTRATION OF THE EFFICACY OF DIVERSIONARY FENCING IN AN ORCHARD WITH A HISTORY OF SERIOUS DEER DAMAGE

EFFICACITÉ D'UNE CLÔTURE DE PROTECTION CONTRE LES CHEVREUILS DANS UN VERGER

Greg G. Sweetland[1]

Partner/Partenaire: New Brunswick Apple Marketing Board / Producteurs de pommes du Nouveau-Brunswick

Abstract: A diversionary fence was constructed in December of 1998, to test and demonstrate the efficacy of diversionary fencing in an apple orchard with a history of serious deer damage. Due to unfavorable working conditions, construction of the fence was not completed for the 1998-1999 winter season. As a result, deer were able to penetrate gaps in the structure and continue to cause serious damage to trees. In the spring of 1999, 15 trees were randomly selected and rated for deer damage (D) from three orchard blocks, with the west, center and east blocks showing average deer damage ratings of D=6.2, D=3.6, D=7.0, respectfully. Final construction of the fence was completed in the fall of 1999. In the spring of 2000, 15 trees were randomly selected and rated for deer damage (D) from three orchard blocks, with the west, center and east blocks showing average deer damage ratings of D=0, D=1 and D=1, respectively. Further observations indicated that signs of deer activity were minimal inside the perimeter of the fence. However, signs of deer activity were observed along the outside perimeter of the fence, indicating that the fence prevented deer from entering into the orchard and feeding on apple trees. Observations should be taken in subsequent years to address variations in snow cover from season to season.

Résumé : Une clôture de protection a été construite en décembre 1998 pour vérifier dans quelle mesure elle pouvait protéger un verger qui a déjà été fortement endommagé par les chevreuils. À cause des conditions de travail défavorables, la clôture n'était pas terminée avant l'hiver 1998-1999. Par conséquent, les chevreuils ont pu pénétrer dans le verger et endommager gravement les pommiers. Au printemps 1999, on a choisi au hasard et évalué 15 arbres pour déterminer les dégâts causés par les chevreuils dans trois parcelles du verger; les parcelles de l'ouest, du centre et de l'est ont présenté respectivement les dégâts moyens suivants : D = 6,2; D = 3,6 et D = 7. La construction de la clôture était terminée à l'automne 1999. Au printemps 2000, on a choisi au hasard et évalué 15 arbres pour déterminer les dégâts causés par les chevreuils dans trois parcelles du verger; les parcelles de l'ouest, du centre et de l'est ont présenté respectivement les dégâts moyens suivants : D = 0, D = 1 et D = 1. D'autres observations ont indiqué que l'activité des chevreuils était très réduite dans le périmètre de la clôture. Toutefois, on a observé des signes de la présence des chevreuils à l'extérieur du périmètre de la clôture, ce qui indique que la clôture a empêché les chevreuils de pénétrer dans le verger et de se nourrir dans les pommiers. Il faudra mener d'autres études au cours des prochaines années pour vérifier l'incidence des différents taux d'enneigement d'une saison à l'autre.

Introduction

Deer damage to both young non-bearing and mature trees in certain locations in New Brunswick has become an increasingly significant problem. Although deer damage can occur at any time of year, the bulk of the damage occurs over the winter months when deer browse on fruit buds that were set the previous fall. Fruit buds, higher in carbohydrates than vegetative buds, are the first choice for deer when feeding. The loss of fruit buds during the winter and spring, reduces crop yields at harvest, and can contribute to biennial bearing. With returns from the apple market falling due to world-wide competition, the only way to maintain competitiveness is to increase yields. Although it is difficult to gauge the economic loss due to deer feeding, damage is occurring at a high enough level that growers are resorting to extreme measures to control the damage.

---

[1] Potato and Horticulture Branch, NBDARD, Fredericton, NB E3B 5H1/ Direction de la pomme de terre et horticulture, MAARNB, Fredericton, NB E3B 5H1

Numerous methods of control are available to apple growers, however, these have had limited success. Electric fencing has proven to be difficult to maintain as snow cover accumulates. Odors, noise makers, and visual deterrents have limited success for short periods of time until the deer become habituated. Certain regions in Canada and USA have constructed full scale exclusionary and diversionary deer fences, as a physical barrier to deer. This form of deer control has been investigated by growers in New Brunswick, but never implemented. Exclusionary deer fences are closed on all sides, while diversionary fences are open at one end.

In the spring of 1998, an application through the NB Strategic Partnership Development Fund was submitted by the NB Apple Marketing Board. This project proposed to demonstrate the efficacy of diversionary fencing in an orchard with a history of serious deer damage. The location of this project was Orchard Shade Farms in Woodstock, NB. In support of this project, the NB Apple marketing Board wanted to demonstrate this technology to horticulture producers in NB. The project was again a cooperative effort between NBDARD and the NB Apple Marketing Board.

Materials and Methods

The NB Department of Natural Resources (DNRE) provided minimal standards for the proposed diversionary structure according to site-specific details. The minimum standards for deer proof fencing are:

Page wire:	maximum opening: 6"x6", wire size14 gauge, wire design: knotted or hinged to reduce sliding of strands
Posts:	9 feet high , 4 feet buried depth, 30 feet distance between posts
Gates:	9 feet high, openings no greater than 6"x6", maximum 6" distance from gate bottom to ground
Construction:	8 feet of page wire, made up of two 4' rolls to be fastened to posts. Bottom wire of fence attached to post at 3" maximum from ground.

> Fence wire secured to posts with staples at every second strand on bottom of roll and at every third strand on top roll. Strands also stapled where bottom and top rolls meet.
>
> Top wire of bottom fence roll and bottom wire of top fence roll shall be wired together at the midpoint between posts.
>
> Single strand wire attached to posts at 9 feet above ground.
>
> A continuous, single-stranded electric wire or hot-tape attached to posts at 30-36 inches above ground, enclosing the fence area on the outside.

A decision was made to construct a diversionary fence as opposed to an exclusionary fence (Figure 1). The design aimed to disrupt deer feeding patterns, while not disrupting equipment access at the lower end of the orchard. Construction began in December of 1998, but due to time constraints and weather conditions, finishing work was not completed until December 1999, ready for the 1999-2000 winter. Observations of damage were taken in spring of 1999 and 2000. The orchard was broken into 3 blocks (West, Center and East). Five trees from each of the three blocks were selected at random and rated from 0 to 10 for deer damage(D), where D0= no damage (0%) and D10= severe damage (100%). Observations were also taken of activity and signs outside the perimeter of the fence. An adjacent orchard outside the perimeter of the fence was rated for deer damage in the same manner. The owner/producer also provided his observations of the fence during both winters.

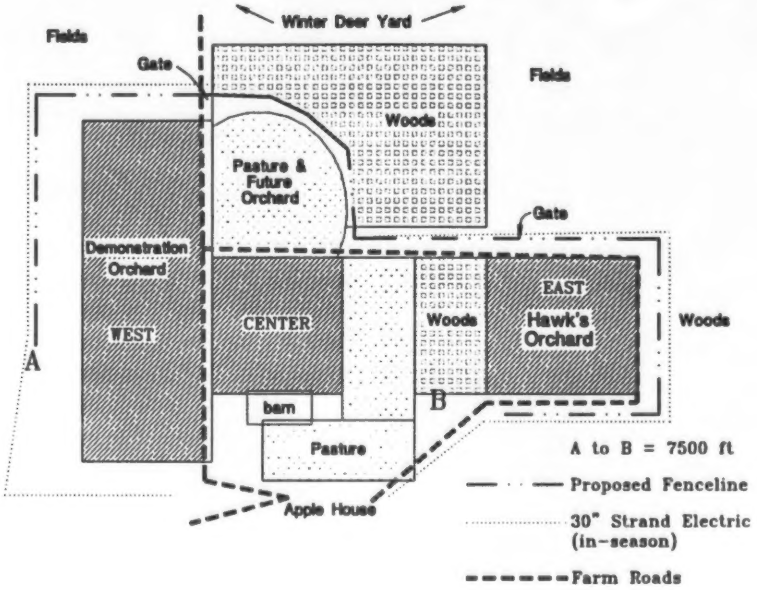

Winter Deer Yard
Fields
Gate
Fields
Woods
Pasture & Future Orchard
Gate
Demonstration Orchard
WEST
CENTER
Woods
EAST
Hawk's Orchard
Woods
A
B
barn
Pasture
Apple House
A to B = 7500 ft
Proposed Fenceline
30" Strand Electric (in-season)
Farm Roads

Figure 1. Layout of Deer Fencing Demonstration Project

Results and Discussion

Again, due to time constraints and unfavorable working conditions, finishing work on the fence was not completed in the fall of 1998 for the winter of 1999. The main fence structure was in place, however, the absence of the offset electric wire and gaps in the fence allowed the deer to enter the orchard at a number of locations. Nonetheless, damage ratings and observations were taken in the spring of 1999 to be used as a comparison to damage in subsequent seasons. Results indicated that damage was serious during the 1999 winter season. The west, center and east blocks showed average deer damage to be D=6.2, 3.6, and 7.0 respectfully (Table 1). However, observations made by the producer/owner during the 1999 winter indicated that damage was minimized by 30 to 40%. Other observations showed significant signs of deer activity both inside and outside the perimeter of the fence.

Finishing work, including closure of gaps and installation of the offset electric wire was completed in the Fall of 1999. This allowed the completed fence to endure a winter season for observations in the spring of 2000.

Table 1. Average Deer Damage Ratings March 1999

Block	Damage Rating (D)*
West	6.2
Center	3.6
East	7.0

Table 2. Average Deer Damage Ratings March 2000

Block	Damage Rating (D)*
West	0
Center	1
East	1

Table 3. Average Deer Damage Ratings Outside Perimeter March 2000

Block	Damage Rating(D)*
Outside West	2.4

(D0= no damage and D10= severe damage)

Deer damage ratings were taken in March of 2000. Results indicated that damage was minimal in all three blocks. The west, center and east blocks showed average deer damage ratings of D=0, D=1 and D=1 respectively (Table 2). Observations made by the producer/owner during the 2000 winter indicated that both deer presence and damage was reduced by 80-90%. Other observations showed minimal signs of deer damage and activity inside the perimeter of the fence, while, many signs of deer activity were observed on the outside perimeter of the fence. Finally, average deer damage ratings for an adjacent orchard outside the perimeter showed moderate to minimal deer damage of D= 2.4 (Table 3).

Results show that deer damage was significantly less during the 2000 winter compared to the 1999 winter. This could be attributed, in part, to the fact that the fence was completely finished for the 2000 winter. In addition, observations taken in the spring of 2000 indicated that deer activity was heavier on the outside perimeter of the fence, than inside, indicating that deer were prevented from entering inside.

During both winters, observations indicated that a small number of deer managed to find the opening at the bottom of the fence. However, it appears that the diversionary layout did disrupt deer patterns at the top of the orchard where deer pressure was highest.

In addition, snow cover varies from year to year and the 2000 winter received less accumulation of snow on the ground than the previous winters. Therefore, deer may have been able to forage at the ground level easier than the previous year, preventing deer from resorting to feeding on apple trees. Further observations and ratings should be taken over the next few years to ensure accuracy of results.

Conclusion

Initial results of the first two years of this project have demonstrated that both deer presence and feeding damage on apple trees can be reduced by the construction of a diversionary deer fence. However, subsequent observations would be necessary to address the variations experienced from season to season.

Acknowledgements

The author wishes to thank George Dukeshire, owner/operator of Orchard Shade Farms in Woodstock, NB for their contribution to this project.